American Pain Society
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TREATMENT
ADVOCACY
PUBLISHED BY ELSEVIER

The Journal of Pain, Vol 16, No 5 (May), 2015: pp 463-471
Available online at www.jpain.org and www.sciencedirect.com

Decreased Sensitivity to Thermal Stimuli in Adolescents With Autism Spectrum Disorder: Relation to Symptomatology and Cognitive Ability

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Abstract: **Social communication deficits and repetitive behaviors are established characteristics of autism spectrum disorder (ASD) and the focus of considerable study. Alterations in pain sensitivity have been widely noted clinically but remain understudied and poorly understood. The ASD population may be at greater risk for having their pain undermanaged, especially in children with impaired cognitive ability and limited language skills, which may affect their ability to express pain. Given that sensitivity to noxious stimuli in adolescents with ASD has not been systematically assessed, here we measured warm and cool detection thresholds and heat and cold pain thresholds in 20 high-functioning adolescents with ASD and 55 typically developing adolescents using a method-of-limits quantitative sensory testing protocol. Adolescents with ASD had a loss of sensory function for thermal detection ($P < .001$, both warm and cool detection thresholds) but not pain threshold ($P > .05$, both heat and cold pain thresholds) in comparison to controls, with no evidence for significant age or sex effects ($P > .05$). Intelligence quotients and symptomatology were significantly correlated with a loss of some types of thermal perception in the ASD population (ie, warm detection threshold, cool detection threshold, and heat pain threshold; $P < .05$). Decreased thermal sensitivity in adolescents with ASD may be associated with cognitive impairments relating to attentional deficits. Our findings are consistent with previous literature indicating an association between thermal perception and cortical thickness in brain regions involved in somatosensation, cognition, and salience detection. Further brain-imaging research is needed to determine the neural mechanisms underlying thermal perceptual deficits in adolescents with ASD.**

Perspective: ***We report quantitative evidence for altered thermal thresholds in adolescents with ASD. Reduced sensitivity to warmth, coolness, and heat pain was related to impaired cognitive ability. Caregivers and clinicians should consider cognitive ability when assessing and managing pain in adolescents with ASD.***

Key words: *Cognition, pain, perception, autism, human.*

Received August 29, 2014; Revised January 21, 2015; Accepted February 4, 2015.

Funding for this work was provided by the Hospital for Sick Children (EGD) and the Canadian Institutes of Health Research New Emerging Team Grant (CIHR; P.A.M. and K.D.D.). P.A.M. is the founder and an employee of Pain Innovations, Inc, London, Ontario. None of the other authors have any conflicts of interest to disclose.

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1526-5900/$36.00

http://dx.doi.org/10.1016/j.jpain.2015.02.001

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by a range of behavioral, communication, and socialization impairments as well as sensory abnormalities.[3,27] Although much research and clinical attention has focused on communication and socialization, relatively less research has focused on sensory abnormalities, particularly altered pain reactivity, which may contribute to children's withdrawal behaviors and

psychosocial difficulties. The *Diagnostic and Statistical Manual of Mental Disorders* (fifth edition) criteria[1] for ASD now includes touch and pain abnormalities, highlighting the importance of the study of their etiology and characteristics. Furthermore, better understanding of pain processing in children and adolescents with ASD has important clinical implications as their pain may be undermanaged because of impaired cognitive and linguistic abilities.

Pain hyporeactivity is an established characteristic of ASD[26,51] but has largely been inferred from clinical or caregiver reports.[36-38,47] For example, Ornitz and colleagues wrote, "Painful stimuli are often ignored; the children may not notice painful bumps, bruises, cuts, or injections."[41] Reduced reactivity to pain in ASD has been related to disruptions in the endogenous opioidergic system.[39,47] In a clinical setting, children with ASD with reduced displays of pain behavior and nonspecific stereotypic behaviors may not receive effective treatment, as clinicians may fail to recognize the presence or source of pain. Clinicians can underrate pain even in non-ASD children experiencing acute pain[33]; this may be more common in ASD, where severity and cognitive impairments may contribute to inaccurate perceptions. For instance, parents perceive their cognitively impaired children as being less reactive to pain in comparison to typically developing (TD) children.[15] Therefore, it is important to understand pain sensitivity in ASD in relation to symptomatology and cognitive ability to improve both clinicians' and caregivers' awareness.

In strong contrast are reports that some individuals with ASD exhibit hypersensitivity to various sensory modalities, including somatosensory, to the extent that they avoid physical contact.[2,5,21] Evidence suggests that adults with ASD can have heightened vibrotactile discrimination capabilities.[5] Cascio and colleagues assessed tactile and thermal sensitivity using a quantitative sensory testing (QST) protocol in high-functioning (intelligence quotient [IQ] >70) adults with ASD[6] and found them to have heightened tactile thresholds. Heat pain threshold (HPT) assessed using a method-of-limits protocol[53] was reported to be lower in individuals with ASD. Results suggest enhanced somatosensory perception. However, both previous studies tested small samples (N = 8) of adults with ASD. Published findings to date have largely been with adult ASD populations, which was a motivating factor to conduct the present study with adolescents with ASD.

In the current study, we tested the hypothesis that adolescents with ASD would exhibit alterations in temperature sensitivity relative to their TD counterparts during a QST of thermal detection thresholds for innocuous and noxious stimuli. Thermal thresholds were compared between groups to assess differences in somatosensory functioning. Furthermore, within the ASD group, the influence of cognitive ability on thermal detection and thresholds for heat and cold pain was assessed.

Methods

Participants

Seventy-six adolescents participated in the study. Twenty participants had received a clinical diagnosis of ASD (75% boys, n = 15, mean age = 14.6 years, standard deviation [SD] = 1.9 years, 18 right-handed) by a psychologist or a developmental pediatrician, which was confirmed using the Autism Diagnostic Observation Schedule–Generic (ADOS-G)[30] (Table 1) administered by personnel who had research-level reliability with the University of Michigan Autism & Communication Disorders Centre. All ASD participants were healthy, were verbal, and had IQs in the normal range (mean = 104.1 $\pm$ 18.27), scoring higher than 70 (scores 2 SDs lower than the mean are considered low functioning) when assessed with the Wechsler Abbreviated Scale of Intelligence. Two male and 2 female participants were taking medication for comorbidities such as attention-deficit disorder, repetitive behaviors, and depression at the time of study (methylphenidate, gabapentin [for mania-like behaviors], ziprasidone hydrochloride monohydrate, selective serotonin reuptake inhibitors). The ASD cohort was recruited through fliers at the Autism Research Unit at the Hospital for Sick Children.

A total of 56 TD adolescents (48% boys, n = 27, mean age = 15.7 years, SD = 1.1 years, 49 right-handed) were recruited to collect normative data to compare thermal thresholds acquired in adolescents with chronic pain.[34] The TD adolescents were slightly older than those in the ASD group (t = 2.2, P = .03); however, the numbers of boys and girls in the 2 groups did not differ significantly (χ^2 = 3.7, P = .053). The TD adolescents were screened for developmental delay; however, cognitive ability (IQ) was not assessed as part of this protocol. The participants were recruited through advertisements in a free community-based newspaper and hospital flyers. This age group was selected for reasons related to feasibility and compliance with study procedures.

The research ethics board at the Hospital for Sick Children approved the study, and written informed consent was obtained from parents and informed assent from all adolescents, including the adolescents with ASD.

Table 1. Measures of Cognitive Ability and Autism Symptom Severity

Measure	*Range*	*Mean*	*SD*
WASI (n = 17)	71–138	104.4	16.9
ADOS-G (n = 14)			
Communication domain		2.6	1.3
Social domain		7	2.0
Restricted-repetitive behavior		2.4	1.2
ADOS-G severity metric* (n = 9)	4–9	6	1.9

Abbreviation: WASI, Wechsler Abbreviated Scale of Intelligence.
NOTE. Standardized measures for IQ included the WASI, and autism symptom severity was determined using the ADOS-G.
*The ADOS-G severity metric was calculated for the 9 participants who were assessed using module 3. The remaining participants were assessed using module 4, which is not included in the severity metric.

Quantitative Sensory Testing

During each testing session, one female investigator administered the thermal stimuli to the participants in a temperature-controlled room. The majority of testing sessions were conducted without parental presence. Standardized instructions for the delivery of the thermal stimuli were given to the participants prior to testing. Participants were seated in a comfortable chair, positioned so that the information on the computer monitor was not visible during the testing. Participants were asked to keep their eyes open during the session to help maintain intersubject reliability. Sufficient time was given for the participants to adapt to the room temperature and be introduced to the equipment. The testing site chosen was the volar (inner) surface of the dominant forearm 10 cm proximal to the skin crease at the wrist.[21]

Thermal thresholds were measured with a Medoc Neuro Sensory Analyzer TSA-II (Medoc Ltd, Ramat Yishai, Israel) using a Peltier-type contact thermal stimulator (TSA 2001, Medoc) and a 30 × 30 mm (9.0 cm^2) contact thermode positioned and maintained in a constant position to ensure uniform skin contact by the investigator. Study participants were able to remove the probe at any time. For safety purposes, temperatures for the heat and cold stimuli were limited to 50°C and 0°C, respectively.

To familiarize the participants with the stimuli, each participant received one of the test temperature stimuli prior to the experimental trials as preexposure in a method-of-limits task, which is known to improve reliability and consistency of the assessment.[54]

Thermal stimuli (warm, cool, heat, cold) were administered in 4 separate trials in the same structured sequence using the method-of-limits protocol.[54] This procedure entailed the computer-controlled delivery of the thermal stimuli, and the adolescents were instructed to indicate when they first felt the modality being tested (ie, warmth detection threshold [WDT], cool detection threshold [CDT], HPT, and cold pain threshold [CPT]) by pressing a mouse button with their contralateral index finger.

Participants' WDTs, CDTs, HPTs, and CPTs were assessed in 4 separate trials per a standard protocol controlled by Medoc WinTSA software. For WDT and CDT, the temperature was increased (for WDT) or decreased (for CDT) from the baseline (32°C) at a rate of .5°C/s. Participants were instructed to press a button with their contralateral index finger when they first felt a sensation of warmth or coolness. The temperature was then returned to baseline at a rate of 10°C/s. The intertrial interval was at least 6 seconds. Four trials were performed, and the mean temperature was calculated to determine the WDT or CDT.

HPTs and CPTs were determined by increasing (for HPT) or decreasing (for CPT) the temperature from baseline (32°C) at a rate of 1°C/s. Participants were instructed to press a button when they felt heat or cold pain. The temperature was then returned to baseline at a rate of 10°C/s. The intertrial interval was at least 20 seconds, and 3 trials were performed. The mean of 3 experimental trials was accepted as the HPT or CPT. Three trials were selected for the heat and cold pain trials to minimize adaption or sensitization effects.

Data Evaluation

The distribution properties of the detection and threshold temperatures were assessed according to the methods described in Rolke et al.[44] In brief, the data were assessed for normality through the calculation of the skewness, kurtosis, and Kolmogorov–Smirnov's d statistic for the raw mean temperatures and log-transformed data. For CPT data, a constant of .1 was added to the temperatures in order to utilize data points of 0°C according to the methods described in Rolke et al.[44] The log-transformed data are considered to be of improved quality when the ratio of raw to log-transformed data is greater than 3.[44]

Statistical Analysis

Data were analyzed using SPSS, version 20 (IBM Corp, Armonk, NY). Between-group thermal detection and pain threshold data were analyzed in a multivariate general linear model, with age and sex as covariates. Within-group analysis of thermal detection and threshold data in the ASD group was correlated with IQ and measures of ASD symptomatology (communication, social responsiveness, and repetitive behaviors subscales of the ADOS-G).

Results

The QST protocol was administered to all ASD participants. One TD participant did not participate in the QST experiment, leaving a total of 55 participants in the TD sample. The thermal sensory testing took 15 to 20 minutes to complete, including practice stimuli. One ASD participant preferred to indicate verbally to the investigators when to stop the stimuli instead of stopping the stimuli using the mouse button. One male adolescent with ASD experienced rapid adaption effects to the stimuli and had difficulty determining the differences between hot and cold temperatures. In addition, this adolescent and 5 others with ASD reported paradoxical heat sensations in response to the first cold pain stimulus that was perceived as burning heat. The data from these participants were evaluated in separate analyses to assess consistency with the other participants' data, which were gathered using the standard protocol without reports of atypical sensory responses.

The raw and log-transformed thermal detection and threshold data were assessed for normality (Table 2). The ratio between the raw and log data did not exceed a value of 3. Therefore, the raw temperature data were used for all subsequent analyses.

Thermal Detection and Pain Threshold Levels

Significant differences in thermal detection and pain thresholds were evident between the groups ($F = 7.33$, $P < .001$; Fig 1). Detection and pain data were not influenced by age ($F = 1.91$, $P = .12$) or sex ($F = 1.76$, $P = .15$). When data from the 1 participant who indicated her

Table 2. QST Parameters for Adolescents With ASD and TD Adolescents

	Mean ± SD (°C)		Skewness		Kurtosis		Kolmogorov–Smirnov's d		Weighted		
Parameter	Raw Data	Log Data	Raw Data	Log Data	Raw Data	Log Data	Raw Data	Log Data	Raw Data	Log Data	Weighted Ratio (Raw/Log)
Adolescents with ASD (n = 20)											
WDT	36.11 ± 3.06	1.56 ± .04	.91	.84	.65	.79	.267	.257	.21	.18	1.12
CDT	26.63 ± 5.1	1.42 ± .1	1.70	2.12	2.04	5.50	.243	.251	.45	.86	.53
HPT	41.49 ± 4.9	1.62 ± .05	.21	.02	.89	.96	.117	.122	.05	.02	2.99
CPT*	15.93 ± 10.08	16.03 ± 10.08	.32	.32	1.1	1.10	.167	.167	.1	.1	1.00
TD adolescents (n = 55)											
WDT	34.03 ± 1.2	1.53 ± .01	2.17	2.05	5.74	5.14	.165	.158	.58	.86	.68
CDT	30.65 ± 1.21	1.49 ± .01	2.68	2.82	8.81	9.71	.191	.196	.93	1.02	.91
HPT	39.79 ± 3.42	1.6 ± .04	.66	.51	.572	.75	.126	.106	.08	.07	1.18
CPT*	17.12 ± 9.62	18.08 ± 10.41	.51	.51	1.26	1.26	.197	.197	.16	.16	1.00

NOTE. Baseline temperature = 32°C. Weighted ratios for the QST parameters were less than 3, and data transformation is not recommended.[19]
*Note that a constant (.1) was added to CPT prior to the log transform.

thresholds verbally to the investigators were removed, similar results were found for group (F = 7.2, $P < .001$), age (F = .15, $P < .06$), and sex (F = .09, $P = .21$). The participant's data, therefore, were included in further analyses. Additionally, when the data for the 6 boys who perceived the noxious cold stimuli as noxious heat were also removed from the analyses and the results were maintained, significant between-group differences (F = 9.3; $P < .001$), but not age (F = 1.1; $P = .4$) or sex (F = 1.9; $P = .1$) effects, were found. Therefore, the data from the 6 participants were included in subsequent analyses as their data did not significantly alter the results based on the full cohort.

The findings for the QST parameters were largely driven by differences in warm and cool thresholds. Individuals with ASD were found to have significantly increased thresholds for warm detection (average WDT temperature difference: 2.3°C, F = 64.13, $P < .001$), whereby the adolescents with ASD only detected a change in warmth when the stimuli were at a higher temperature relative to the controls. Similar results were found for CDT, with adolescents with ASD having significantly lower thresholds for cool stimuli (average CDT temperature difference: 4.3°C, F = 169.7, $P < .001$), where the adolescents with ASD detected the cool stimuli at a lower temperature relative to the TD adolescents. Although trends were seen for the pain threshold data, no differences between groups were significant (average HPT temperature difference: 1.5°C; F = 36.19, $P = .16$; average CPT temperature difference: 2.0°C, F = 1.45, $P = .91$). Between-group differences in the relative change among the detection thresholds and the baseline temperature (32°C) were also assessed. A significant main effect for group was found (F = 7.3, $P < .0001$), with the CDT (F = 21.0; $P < .0001$) being lower and the WDT (F = 24.1; $P < .001$) being significantly higher in the ASD cohort relative to the controls.

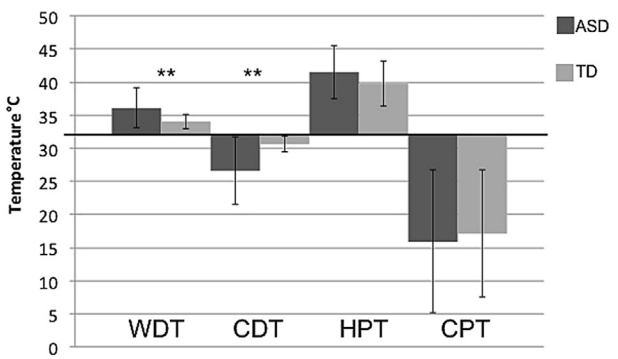

Figure 1. QST results: Adolescents with ASD (dark gray bars) showed significantly higher WDTs and lower CDTs compared to TD controls. No significant between-group differences were evident for HPT and CPT. Error bars represent SDs. **$P < .001$.

Given the disproportions in sex and hand dominance between the groups, a subset of the data from the TD adolescents was selected for comparison (n = 20 [15 males], mean age = 15.23 years, SD = 1.2 years, 19 right-handed). The participants were selected to match the 20 ASD adolescents based on their age, sex, and hand dominance. The 20 TD adolescents did not differ significantly in terms of hand dominance ($P = .4$, Fisher's exact test) in comparison to the other 35 TD adolescents; however, significantly fewer girls were included in this group ($\chi^2 = 8.4$; $P = .004$), and the participants were younger (t = 2.4, $P = .02$). Then, the same analyses were performed on the QST data from the 20 ASD and 20 TD adolescents. Similar results were obtained as in the analysis with the full cohort: the data showed a significant main effect for group (F = 3.03, $P = .03$); there were no effects of age (F = 2.12, $P = .1$) or sex (F = .95, $P = .45$); and thermal detection thresholds were significantly different (WDT: F = 47.01, $P = .004$; CDT: F = 139.6, $P = .002$), with no effects seen in the thermal pain data (HPT: F = 50.3, $P = .09$; CPT: F = 15.97, $P = .69$).

The sensory profile of the ASD population was calculated according to the methods described in Rolke et al[44] using reference data from the 20 matched controls (Fig 2). Results indicated significantly reduced warm and cool sensitivity in the ASD population.

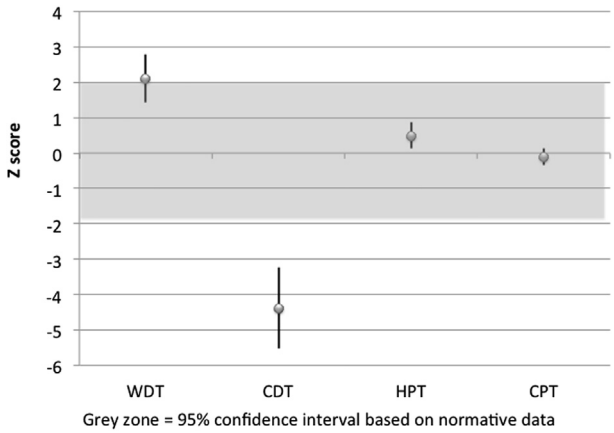

Figure 2. Sensory profiles in adolescents with ASD in comparison to TD adolescents. Raw data in the ASD population were z-transformed by subtracting the mean values of the WDTs, CDTs, HPTs, and CPTs obtained in the TD adolescents. The sensory profile of the ASD population indicates a predominant loss of sensory function, particularly for the cool stimuli (CDT), where the mean is outside the 95% confidence interval range of the TD population (gray zone).

QST Parameters, Cognitive Ability, and Autism Severity

In the ASD group, 17 of the 20 underwent intelligence testing (see Table 1). The thermal detection thresholds for the ASD group (n = 17; WDT: r = −.8, $P < .001$; CDT: r = .59, $P = .01$; Fig 3) and their HPTs (r = −.51, $P = .04$) were correlated with IQ, but their CPTs were not significantly correlated with IQ (r = .4, $P = .11$). Autism severity was assessed using the ADOS-G in 14 adolescents with ASD (Table 1) and was correlated with thermal detection (WDT: r = .64, $P = .01$; CDT: $P < .05$) levels. No correlation was found between pain thresholds and autism severity (HPT: r = .36, $P = .2$; CPT: r = −.3, $P = .3$). As the ADOS-G is composed of 3 subtests (social, communication, and repetitive behavior domains), we subsequently tested the correlation between each of the subtests with the thermal detection thresholds (WDT, CDT). Results indicated that lower scores on the social (WDT: r = .62, $P = .02$) and communication (CDT: r = −.67, $P = .01$) domains were significantly correlated with thermal detection thresholds. No correlation between scores on the repetitive behavior domain and thermal detection levels was evident ($P > .05$).

Discussion

Using a standard method-of-limits QST protocol, we demonstrated that high-functioning adolescents with ASD had significantly higher WDTs and lower CDTs relative to control adolescents, with no evidence of significant differences in thermal pain thresholds. Thermal detection and thresholds were only partially associated with cognitive ability and autism symptom severity. Therefore, cognitive impairments in the ASD sample may partly explain significant differences in WDTs and CDTs. However, the alterations in thermal perception thresholds may also reflect physiological differences in the ASD population, reflecting changes in peripheral or central somatosensory processing systems.

Reduced Thermal Sensitivity in ASD

Adolescents with ASD were less sensitive to warm and cool stimuli compared to their TD counterparts, with warm detection temperature thresholds being higher and cool detection temperature thresholds lower in ASD. HPTs and CPTs were not significantly abnormal; however, trends were seen in the ASD population toward increased HPT and decreased CPT relative to the reference data. Our findings are in contrast to a previous study with high-functioning adults with ASD that indicated no difference in thermal detection thresholds compared to adults without ASD.[6] The previous adult study also used a method-of-limits protocol; however, the sample differed in terms of age, number of subjects (N = 8), and cognitive ability, which may explain some of the discrepancies between the results.

Thermal detection and pain thresholds in the ASD population were only partially explained by IQ and autism severity. Findings of reduced thermal detection capabilities in the ASD sample may be a result of cognitive deficits such as difficulties with reorienting attention combined with a dampened arousal response.[4,29] Deficits in reorienting or shifting attention have been reported in children with ASD, especially in relation to auditory stimuli, relative to controls.[7,24] The adolescents with ASD in the current study may have been exhibiting a reduced ability to shift attention to innocuous stimuli, but as the noxious stimuli were highly salient, this may have promoted a shift in attention, resulting in thermal thresholds comparable to those of the TD adolescents.

Given that not all thermal detection and pain thresholds were correlated with measures of cognitive ability and autism severity, the results may also reflect alterations in peripheral processing of warm and cool stimuli. Warmth perception is mediated by specific warm receptors on unmyelinated C fibers that are excited by temperatures in the innocuous range.[9,10,18,23] In contrast, the perception of burning heat pain is attributed to the excitation of C-polymodal nociceptors. Sharp pricking pain sensation evoked by noxious heat is transmitted through the excitation of A-delta nociceptors. Adults with small-sensory-fiber dysfunction involving the loss of unmyelinated C fibers will have impaired warm sensation but preserved thermal pain sensation.[49] In relation to the current work, the reduction in thermal sensitivity in adolescents with ASD could potentially be related to a depopulation or alteration in the functional organization of unmyelinated C fibers. Electroneurographic examination would be needed to address this question.

Reduced thermal sensitivity in the ASD sample may also be explained by alterations in the cortical somatosensory system. Previous research with TD adults and children with ASD has indicated that thermal perception thresholds and pain behaviors are related to thickness in brain regions that process sensory discriminative

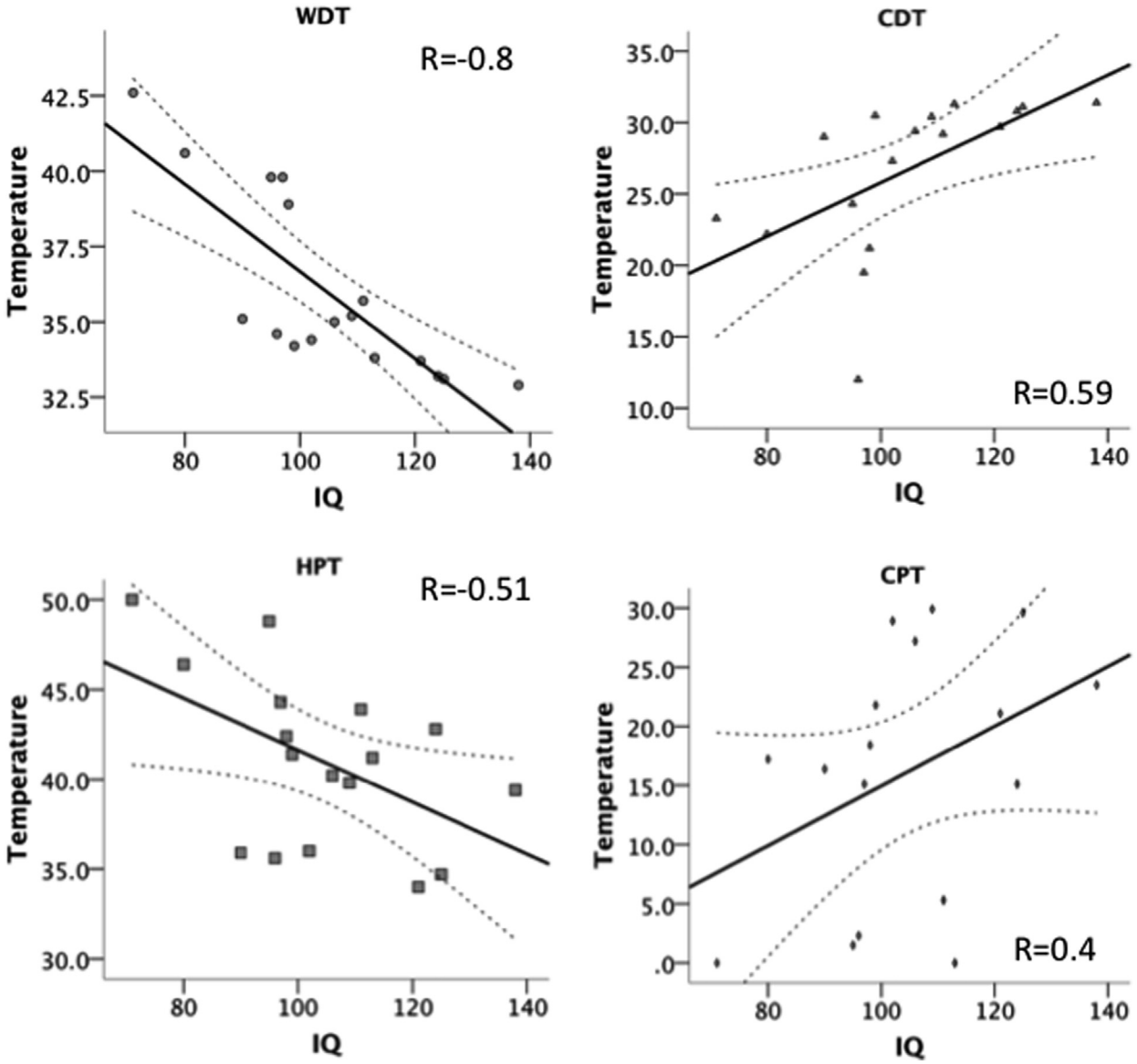

Figure 3. Thermal detection (WDT and CDT) and pain (HPT and CPT) thresholds correlated with IQ scores obtained on the Wechsler Abbreviated Scale of Intelligence in adolescents with ASD. Thermal detection thresholds (n = 17; WDT: r = −.8, $P < .001$; CDT: r = .59, $P = .01$) and heat pain threshold (r = −.51, $P = .04$) were associated with IQ. CPT was not correlated with IQ (r = .4, $P = .11$). Analyses were performed using Pearson's correlation, with the alpha level set at .05. Dashed lines represent 95% confidence intervals.

aspects of thermal perception such as the primary somatosensory cortex.[13,14,17] Whether a similar neural mechanism of reduced cortical thickness underlies alterations in thermoperception in ASD remains unknown, but it could be the focus of future studies.

Quantitative Sensory Testing in Children

Current methods to assess sensory thresholds were developed in adult populations to assess peripheral neuropathies and centrally mediated or trauma-related pathologies. Although QST has been used relatively less to assess somatosensory functioning in children, the reference site cool and warm thresholds in the present study are within the published range of thermal detection thresholds in TD children and adolescents.[22,35] Thermal detection was significantly altered in the ASD population, with children reporting lower CDTs and higher WDTs. In addition, trends were seen for lower CPTs and higher HPTs in children with ASD.

We selected the method-of-limits protocol for reasons related to participant safety and to ensure compliance with the experimental procedures. The method-of-limits protocol is a reaction time task that is dependent on cognitive ability. IQ is directly correlated with reaction time[12]; however, despite this possible bias, the majority of QST studies utilize the method of limits.[19-21,28,31,35,40,42] The method of levels, whereby participants are exposed to noxious temperatures and then asked to rate the intensity of the stimuli, is an alternative to the method of limits.[43] The method of levels would be suitable for high-functioning children and adolescents with ASD and could be used in future psychophysical studies;

however, children with more severe cognitive deficits would be precluded from testing. In the current study, the significant between-group differences between warm and cool thresholds could reflect a slower response time in the ASD adolescents rather than an actual loss of sensitivity to thermal stimuli. However, not all detection and threshold levels were correlated with IQ, indicating that the differences in thermal perception likely have a physiological basis in children and adolescents with ASD.

Paradoxical Heat Sensation

Within the ASD sample, 30% reported a paradoxical heat sensation or a sensation of burning heat pain in response to cold stimulation that was preceded by a warm stimulus, thus indicating a disruption of thermosensory integration. Paradoxical heat sensations have been reported in .6% of the adult male population.[45] Studies of selective A-fiber block in which participants also report burning heat in response to cold[11,16,32,50,52] have provided insight into the mechanisms of paradoxical heat sensations: 1) disinhibition of a heat-sensitive C-fiber pathway either by a blockade or loss of A-fiber input and 2) facilitation of the disinhibited C-fiber pathway by sensitization of primary afferents.[8,46,50,52] In the current sample, paradoxical heat sensations may reflect alterations in the number of small fibers or the degree of small-fiber myelination in adolescents with ASD.

Limitations

The sensory testing protocol involved the administration of standardized instructions to the participants to ensure reliability of the measures. However, other factors not assessed in the current study that may have affected thermal detection and threshold levels include parental presence, anxiety, fatigue, and attention.[25,48,55] Further study into the effects of social, emotional, and cognitive factors on thermal perception in children with ASD is needed. Additionally, improved information on the influence of cognitive ability on performance on the method-of-limits QST protocol in the general population is warranted. In the current study, intelligence testing was not performed in the TD adolescents because of lack of resources.

Conclusions

We performed QST of thermal detection and pain thresholds in high-functioning adolescents with ASD. The thermal detection and threshold data were compared to that collected in TD adolescents. Although some thermal detection and pain thresholds were associated with cognitive ability and severity, results indicate that adolescents with ASD demonstrate a profile of decreased thermal sensitivity. Further research is needed to better characterize these physiological alterations in temperature processing in high-functioning adolescents with ASD to determine whether they are attributable to peripheral or central nervous system abnormalities, or if they are also moderated by psychosocial factors and cognitive ability. Research regarding reactions to pain and discomfort in low-functioning adolescents is also needed as these individuals may be more likely to have their pain undermanaged as a result of communication impairments. Research exploring pain sensitivity during early development in ASD is also warranted as infants who display reduced pain behaviors may show an increase in pain reactivity later in adolescence.

Acknowledgments

The authors thank Dr. Eric J. Crawford and Ms. Tamara Powell for their assistance with the testing procedure. The authors sincerely thank the adolescents and their families for participating in this study.

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