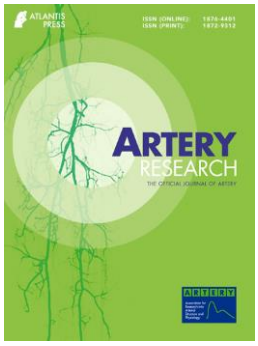

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SHORT COMMUNICATION

Participation in physical activity and arterial stiffness in males with autism spectrum disorder

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Arterial stiffness;
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Abstract Selective eating and hyperphagia are frequently encountered in individuals with autism spectrum disorder (ASD). They may increase arterial stiffness, a risk factor for cardiovascular disease, via excessive sodium intake, nutritional deficiency, and obesity. Therefore, primary prevention of cardiovascular disease is an important issue in this population. To test our hypothesis that greater levels of physical activity are associated with lower levels of arterial stiffness in individuals with ASD as well as those without ASD, this study compared brachial-ankle pulse wave velocity (baPWV) in active males with and without ASD and less active males without ASD. We recruited subjects with ASD via organizations providing opportunities to play sports. Subjects without ASD were subdivided into less and more active groups based on scores from the International Physical Activity Questionnaire. Daily physical activity levels were higher in the more active control (2992 ± 681 MET min/week) and ASD (2992 ± 972 MET min/week) groups than in the less active control group (337 ± 86 MET min/week). BaPWV was lower in the more active control (10.7 ± 0.3 m/s) and ASD (9.9 ± 0.6 m/s) groups than in the less active control group (11.7 ± 0.3 m/s). There were no differences in physical activity level and baPWV between more active males with ASD and those without ASD. These results suggest that physically active males with ASD also have elastic central arteries. We would like to propose that participation in physical activities may be beneficial as a primary cardiovascular disease prevention strategy for not only for males without ASD but also those with ASD.

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Introduction

An unbalanced diet, such as a proclivity to only eat certain foods, refuse certain foods, or both, is frequently encountered in individuals with autism spectrum disorder (ASD).[1] Hyperphagia is also frequently identified in this population; previous studies have reported that 10.0–30.4% of individuals with ASD are obese and 33.6–42.0% are overweight.[2–4] Excessive sodium intake[5,6] and obesity[7] are risk factors for arterial stiffening, although to the best of our knowledge there have been no previous studies investigating arterial stiffness in individuals with ASD. Individuals with ASD may not adequately perceive or describe subjective symptoms, which makes early disease detection more challenging. Hence, primary prevention of cardiovascular disease is an important priority in individuals with ASD. We previously reported that physically active males without ASD have lower arterial stiffness,[8,9] but it is unclear whether this is the case for males with ASD. For example, higher plasma serotonin concentrations in individuals with ASD[10] may affect the association between physical activity and arterial stiffness. To test our hypothesis that greater levels of physical activity are associated with lower levels of arterial stiffness in individuals with ASD as well as those without ASD, we compared brachial-ankle pulse wave velocity (baPWV, an index of arterial stiffness) in active males with and without ASD and less active males without ASD.

Methods

We recruited subjects with ASD via two organizations providing this population with opportunities to play sports. Through these organizations, children or young adults with ASD engage in swimming (60 min $\times$ 1 session/week), walking (75 min $\times$ 5 sessions/week), or other sports activities. In addition, we attempted to recruit subjects with ASD through a welfare organization for individuals with intellectual disabilities. Non-smoking male university students without ASD (control group) were recruited using advertisements and word of mouth. Twelve males and females with ASD from the sports organizations and 21 male university students without ASD volunteered to participate in the study (Fig. 1); we were not able to recruit any participants from the welfare organization. Females, elementary school students, subjects on any medication, obese subjects (body fat >30.0%), and subjects with a congenital vascular anomaly were excluded; the remaining seven subjects with ASD and 19 subjects without ASD were analyzed. Five subjects in the ASD group were diagnosed with autism by physicians. One subject in the ASD group did not have a formal diagnosis, but was sent to the organization by his mother. We could not confirm whether the remaining subject in the ASD group had a formal diagnosis of autism. All subjects with and without ASD were free of signs, symptoms, and history of any overt chronic disease except for ASD. None of them smoked or took dietary supplements. The present study was approved by the Ethical Committee of the Faculty of Health and Welfare Human Services of St. Catherine University. This study conformed to the principles outlined in the Helsinki Declaration. All participants and the guardians of subjects with ASD gave their written informed consent before their participation in this study.

Subjects refrained from alcohol consumption and intense physical activity starting the day before testing, and caffeine consumption on the day of testing. After a resting period at least 10 min in a quiet, temperature-controlled room, baPWV was measured as in our previous study.[11] Briefly, brachial and post-tibial artery pressure waveforms were obtained simultaneously, in triplicate, by cuffs connected to an air plethysmographic sensor and an oscillometric pressure sensor (formPWV/ABI; Omron Colin, Tokyo, Japan). The distance traveled by the pulse wave from the heart to the brachial recording site (Distance A) and that from the heart to the post-tibial recording site (Distance B) were calculated based on each subject's height as follows[12]:

$$\text{Distance A(heart to brachial recording site)} = 0.2195 \times \text{height(cm)} - 2.0734$$

$$\text{Distance B(heart to ankle recording site)} = 0.8129 \times \text{height(cm)} + 12.328$$

The time from when the pulse waves reach the brachial recording site to when they reach the post-tibial recording site (T) was determined based on the time delay between the brachial and post-tibial 'foot' waveforms. The foot of the wave was identified as the commencement of the sharp systolic upstroke, which was detected automatically by the software of the device. BaPWV was calculated as the difference between Distance A and B divided by T. To assess daily physical activity, we interviewed the subjects and the guardians of subjects with ASD using the International Physical Activity Questionnaire (IPAQ).[13]

Intergroup differences in baPWV were assessed using analysis of covariance that included blood pressure as a covariate. Intergroup comparisons of other indices were conducted by analysis of variance. If a significant F value was found, a post hoc Fisher's protected least significant differences test was performed. P values < 0.05 were considered statistically significant.

Results

According to the protocol for the questionnaire, control subjects were subdivided into a less active control group (10 subjects with low levels of daily physical activity) and a more active control group (six subjects with high levels [mean $\pm$ SE, 3914 $\pm$ 763 MET min/week] and three subjects with moderate levels [1148 $\pm$ 324 MET min/week]). There were no differences in age, height, weight, blood pressure, or heart rate across the less active control, more active control, and ASD groups (Table 1). Daily physical activity was greater in the more active control and ASD groups than in the less active control group (Fig. 2). BaPWV was lower in the more active control and ASD groups compared to the less active control group, independent of blood pressure (Fig. 3). There were no differences in daily levels of physical activity and baPWV between the more active control and ASD groups.

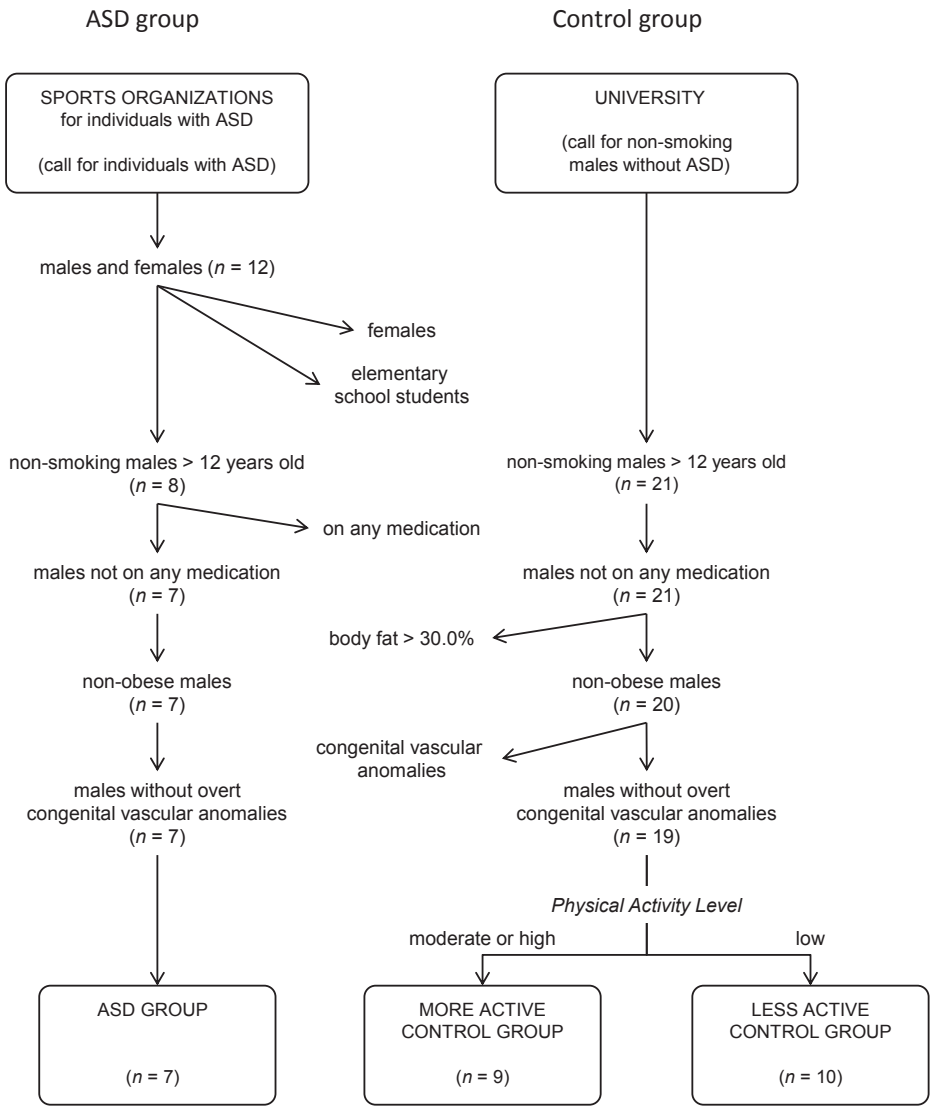

Figure 1 Exclusion criteria for subjects with and without autism spectrum disorder (ASD).

Discussion

This study has the following limitations. First, we were not able to compare more active versus less active individuals with ASD. It is possible that congenital factors or attention deficit hyperactivity disorder are related to lower arterial stiffness in males with ASD, regardless of the level of physical activity. Second, an association between the level of physical activity and arterial stiffness in females with ASD has not been studied. Premenopausal females have

Table 1 Characteristics of study participants.

n	Without ASD		With ASD	*P* value
	Less active	More active		
	10	9	7	
Age, years	20.6 ± 0.3	18.9 ± 0.4	18.4 ± 2.1	0.28
Height, m	1.69 ± 0.02	1.70 ± 0.02	1.69 ± 0.03	0.91
Weight, kg	65.2 ± 2.9	66.2 ± 3.8	58.2 ± 5.7	0.35
Systolic blood pressure, mmHg	118 ± 3	119 ± 4	110 ± 3	0.18
Diastolic blood pressure, mmHg	68 ± 2	68 ± 3	61 ± 3	0.11
Heart rate, bpm	63 ± 4	60 ± 3	64 ± 8	0.84

Values are means ± SEs. ASD, autism spectrum disorder.

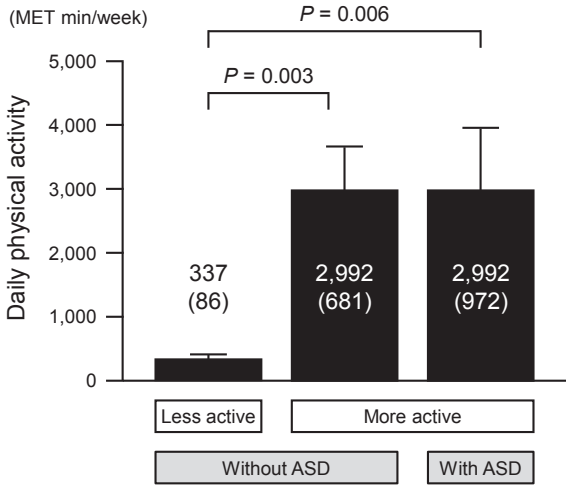

Figure 2 Daily levels of physical activity in males with and without autism spectrum disorder (ASD). Values are means (±SEs).

lower arterial stiffness than age-matched males and older individuals[14]; young females have markedly elastic arteries. It is possible that improvements in arterial stiffness associated with increased physical activity are of a smaller magnitude in young females with ASD than males and older females with or without ASD. Third, we could not collect information regarding dietary habits. In their study, Zimmer et al. found that 10 of 22 subjects with ASD were selective eaters with protein, calcium, and vitamin deficiencies, while the remaining 12 subjects who were not selective eaters were not malnourished.[1] In addition, skipping breakfast,[15] living away from home,[16] and relying on fast food[17] are risk factors for malnutrition in subjects without ASD. It should be noted that the present results may be confounded by nutritional status. Finally, since this study has a small sample size, the present results should be confirmed with larger study populations. However, this is the first study to demonstrate that males with ASD who participate in physical activity have lower arterial stiffness than less active males without ASD, and similar arterial stiffness as more active males without ASD. The present findings do not conflict with our hypothesis that greater levels of physical activity are associated with lower levels of arterial stiffness in individuals with and without ASD.

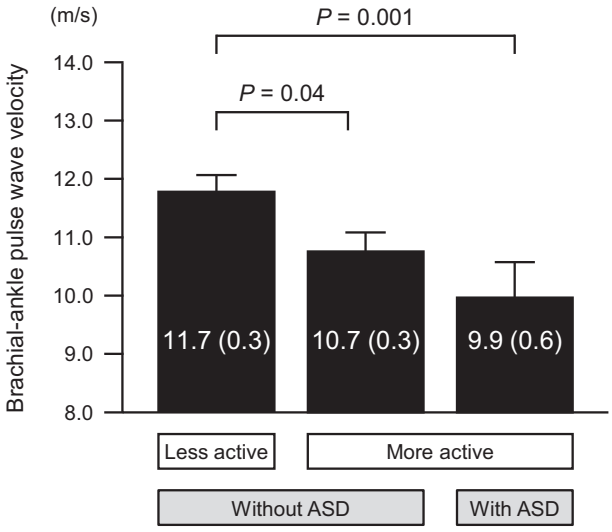

Figure 3 Arterial stiffness in males with and without autism spectrum disorder (ASD). Values are means (±SEs).

We compared physical activity levels based on IPAQ scores. Self-reported physical activity levels have lower validity than measured levels of physical activity. However, one international study group (14 centers from 12 countries) reported that IPAQ scores have an acceptable degree of reproducibility (Spearman's rank-correlation coefficient between two assessments within one week of approximately 0.80) and validity (correlation coefficient between physical activity level estimated by IPAQ and accelerometry values of approximately 0.30) to classify individuals into distinct groups. In the present study, there were appreciable differences in IPAQ scores between the groups; the scores in the more active control and ASD groups were 8.8-fold higher compared to the less active control group. Therefore, we are confident that the more active control and ASD groups had higher levels of physical activity than the less active control group.

This study used baPWV as an index of arterial stiffness. BaPWV is an emerging metric of pulse-wave velocity (PWV) that has been widely used in Japan and other countries over the past decade. Recent studies have reported that associations between coronary artery disease, coronary calcification, or left ventricular hypertrophy and baPWV were comparable to, or somewhat greater than, associations with carotid-femoral PWV (*i.e.*, the most traditional metric of PWV),[18–20] although baPWV assesses both central elastic and peripheral muscular arterial stiffness. One meta-analysis showed that the relative risk of a cardiovascular disease event for a 1.0 m/s increase in baPWV was 1.12, corresponding to a 12% risk increase.[21] The observed differences in baPWV between the less active subjects without ASD and the more active subjects with and without ASD were 1.8 and 1.0 m/s, respectively. Taken together, we propose that participation in physical activities may be beneficial as a primary cardiovascular disease prevention strategy not only for males without ASD but also those with ASD.

Conflict of interest

We declare no conflict of interest.

Acknowledgments

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