AN EXAMINATION OF THE RELATIONSHIP BETWEEN BODY SIZE, ENGAGEMENT IN PHYSICAL ACTIVITY, AND VISUOSPATIAL ABILITY IN CHILDREN

by

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ABSTRACT

Research indicates a relationship between obesity and physical activity, such that higher Body Mass Indices are associated with less physical activity. There also appears to be a possible positive relationship between physical activity and cognitive skills, and a negative relationship between obesity and cognitive skills (e.g., inhibition, cognitive flexibility, and visual spatial processing: VSP). The purpose of this study was to investigate the relationship between body size, physical activity, and VSP in school-aged children. Forty children completed assessments including anthropometrics, two tests of visual perception (Arrows: AW and Geometric Puzzles: GP), and a physical activity measure. Results indicated that AW and GP were significantly positively correlated; AW was not significantly correlated with physical activity. Furthermore, AW was a significant predictor of body size, but neither physical activity nor GP were. The results suggest a potential relationship between visuoperception and body size in children that future research should continue to clarify.

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CHAPTER I

Literature Review

In 2012, approximately 17% of children and adolescents between the ages of 2 and 19 years in the United States were considered obese (Ogden, Carroll, Kit, & Flegal, 2014). Additionally, the Center for Disease Control (2003) reported that in 2002 approximately 61.5% of children between the ages of 9 and 13 years did not participate in organized physical activity outside of school and 22.6% did not take part in physical activity during their free time. Years of research has documented the relationship between obesity and physical activity in adults as well as children (e.g., Anderson, Crespo, Bartlett, Cheskin, & Pratt, 1998; Laurson, Lee, Gentile, Walsh, & Eisenmann, 2014). Recent research has begun to assess the relationship between obesity in children and various areas of cognitive functioning, including executive functioning, memory, verbal behavior, and visual spatial processing abilities (e.g., Gunstad et al., 2008; Jansen, Schmelter, Kasten, & Heil, 2011; Reyes, Peirano, Peigneux, Lozoff, & Algarin, 2015). Although this literature is in its infancy, early findings indicate that problems in some areas of cognitive functioning are associated with unhealthy body size. This review focused on the research assessing body size, physical activity, and various areas of cognitive functioning skills in children, with an emphasis on visual spatial processing abilities. A study then is proposed to assess the potential relationship between unhealthy body size, physical activity, and two types of visual spatial processing skills in school aged children.

Visual Spatial Processing in Children

Visual spatial processing (VSP) is the ability to create, retain, retrieve, and manipulate visual stimuli (Chabani & Hommel, 2014). Voyer, Voyer, and Bryden (1995) differentiated between three categories of VSP ability: spatial perception, mental rotation, and spatial visualization. Spatial perception refers to the ability to determine spatial relations regardless of any distracting information. Mental rotation is the ability to quickly and accurately rotate figures in the mind. Lastly, spatial visualization is defined as the ability to manipulate spatial information when multiple steps are needed in order to reach the final solution (Voyer et al., 1995).

A meta-analysis conducted on sex differences in spatial abilities revealed that males have significantly better VSP skills than females (Voyer et al., 1995). These sex differences were most evident in the tasks of mental rotation ability, however, on tasks of spatial visualization ability, these sex differences were inconsistent (Voyer et al., 1995). Furthermore, sex differences in spatial ability increase with age. The meta-analysis indicated that children under 13 years of age did not show significant sex differences in any category of VSP ability, although participants ages 13 years and older revealed sex differences, particularly on the spatial perception and mental rotation categories (Voyer et al., 1995).

Uttal et al. (2012) conducted a meta-analysis on the malleability of VSP skills using three categories of training: video games, training course, and spatial task training. Training was considered a ‘video game’ if the main purpose was for entertainment and not spatial training (Uttal et al., 2012). The training course involved being enrolled in a course that was likely to have an impact on VSP, such as playing chess or taking a graphics course. The spatial task training involved more practice and strategic instruction; an example of a training included in the meta-analysis is a recreational activity with emphasis on one's spatial orientation. Results indicated that VSP skills are malleable and improve with training (Uttal et al., 2012). Additionally, no differences were found with respect to the type of training utilized; all methods produced similar results in improving VSP.

The ability to take in and manipulate visual information differs between the sexes. This sex difference is most notable in people ages 13 years old and up (Voyer et al., 1995). Furthermore, the specific ability to mentally rotate figures shows the most pronounced gender differences while spatial visualization is rather inconsistent (Voyer et al., 1995). VSP is malleable; participating in training has been shown to improve these skills, regardless of type of training (Uttal et al., 2012). Overall, these results suggest that VSP is not significantly different between males and females under age 13 years (Voyer et al., 1995). It is also suggested that physical activity might be an efficacious training method to improve VSP in children (Uttal et al., 2012).

Physical Activity and Body Size

The influence of physical activity, screen time, and sleep duration on overweight and obesity were investigated in the Laurson et al. (2014) study, which included a sample of normal (Boys: *M*age = 9.7, *SD* = 0.9; Girls: *M*age = 9.6, *SD* = 0.9) and overweight/obese (Boys: *M*age = 9.6, *SD* = 0.9; Girls: *M*age = 9.7, *SD* = 1.0) children from the Midwest. Physical activity was recorded using a pedometer, screen time was represented as the average weekly time spent watching TV and/or playing video games, and sleep duration was assessed using self-report. Results indicated that the overweight/obese children were less active, engaged in more screen time, and slept less than normal weight children (Laurson et al., 2014). Of the total sample of boys (n = 303), only 7% of the obese boys met the physical activity recommendation of 13,000 steps per day, compared to 21.9% of normal weight boys. Similarly, of the total sample of girls (n = 371), only 8.4% of obese girls met the physical activity recommendation of 11,000 steps per day, compared to 19.2% of normal weight girls. A correlational analysis revealed that physical activity was significantly negatively correlated with body mass index (BMI) in girls; however, this relationship was not apparent in boys (Laurson et al., 2014). Furthermore, not meeting the physical activity recommendation was the strongest predictor of obesity (Laurson et al., 2014).

In a similar study, BMI, body fatness, vigorous activity, and TV watching were assessed in a U.S. sample of 8 to 16 year old males and females (Anderson et al., 1998). The amount of physical activity they engaged in and TV they watched was assessed via interview. Boys who reported engaging in vigorous activity 6 to 8 times per week had significantly higher BMIs than boys who engaged in vigorous activity 5 times per week or less. No discernible trend was observed for girls, which is in contrast to the Laurson et al. (2014) study. Girls who watched 4 hours or more of TV per day had significantly higher BMIs than girls who watched 3 hours of TV or less per day. Additionally, boys who watched 2 to over 4 hours of TV per day had significantly higher BMIs than boys who watched less than 2 hours of TV per day (Anderson et al., 1998).

Tremblay and Willms (2003) investigated the relationships between physical activity, sedentary behaviors, and BMI in Canadian boys and girls ages 7 to 11 years. Physical activity and sedentary behaviors were assessed by parent report. Results indicated that participation in unorganized sports was negatively associated with being obese and overweight (Tremblay & Willms, 2003). Additionally, participating in organized sports was negatively associated with obesity, but not with being overweight. Watching TV more than 3 hours per day was identified as a risk factor for obesity while over 2 hours per day was a risk factor for overweight (Tremblay & Willms, 2003).

In Malaysia, a study was conducted that examined the associations between physical activity, sedentary behaviors, and BMI in boys and girls ages 7 to 12 years old (Lee et al., 2015). Physical activity was assessed using a questionnaire that required the children to think of their physical activity over the past week. Furthermore, a subsample wore a pedometer for 7 consecutive days in order to obtain an objective measure of physical activity. Based on the physical activity score and pedometer count, the results suggested that overweight/obese children were significantly less active than normal weight children. Screen time did not differ between the two BMI groups, suggesting overweight/obese and normal weight children engage in similar amount of screen time (Lee et al., 2015). Additionally, the physical activity score and pedometer count were negatively correlated with BMI, which supports the results found in the Laurson et al. (2014) study (Lee et al., 2015).

Taken together, these studies suggest a negative relationship between physical activity and BMI in children. The Anderson et al. (1998) study indicated that the children with the highest BMIs engaged in vigorous physical activity more than children with the lowest BMIs. This is in contrast to the other studies mentioned; it could be that the overweight/obese children in the Anderson et al. (1998) study were engaging in more physical activity in order to become healthier. Despite this discrepancy, there is a clear trend between childhood obesity and physical activity, such that the more physical activity that is engaged in, the lower BMI the child will have (e.g., Laurson et al., 2014; Lee et al., 2015).

Body Size and Cognitive Function

Much of the research concerning childhood obesity has focused on its relationship to physical health issues. However, recent research has focused on the relationship between childhood obesity and cognitive functioning. Some areas of study include inhibitory control, memory, mental flexibility, and visual spatial ability.

Inhibition. Barkley (1997) defined inhibition as suppressing a prepotent response, stopping an ongoing response, and resisting distraction. The Stroop test was used to evaluate inhibition in normal and overweight 10-year-old boys and girls in Chile (Reyes et al., 2015). Results from the Stroop test indicated that children in the overweight category had a longer reaction time than children in the normal weight category, but they did not differ based on error rates (Reyes et al., 2015). Furthermore, the overweight group had longer reaction times in the conflict adaptation sequences, meaning after two control trials, it took them longer to react in the following incongruent trial as compared to the normal weight children (Reyes et al., 2015). Blanco-Gomez et al. (2015) also examined inhibitory control in obese, overweight, and normal weight children 6 to 10 years of age from Spain. The Five Digit Test (FDT), which was adapted from the Stroop test, uses numbers instead of words. The reading and selecting sections of the test were used, with the selecting subscale used to assess the ability to suppress a prepotent response and resist distraction. Results indicated that all groups performed similarly on those two sections. However, when a logistic regression was conducted, inhibition was shown to be a significant predictor of being overweight/obese, indicating a longer reaction time (Blanco-Gomez et al., 2015). The aforementioned studies suggest that overweight and obese children may not differ from normal weight children in terms errors made when suppressing a prepotent response, but they may take longer to react to the stimuli.

Working memory. Working memory, which is the ability to mentally hold and manipulate information in order to complete a task, was assessed using the Digit Span subtest on the WISC-III in a sample of obese and normal weight boys (*M*age = 12.1, *SD* = 0.9) from Hungary (Cserjesi, Molnar, Luminet, & Lenard, 2007). The two groups did not differ on subtest performance, indicating similar ability to maintain and manipulate verbal information (Cserjesi et al., 2007). Similar to Cserjesi et al.'s (2007) study, Gunstad et al. (2008) used Digit Span backward to assess working memory in 6 to 19 year old children and adolescents, except the information was presented visually rather than verbally, and participants had to respond using a keypad. Memory also was assessed using a verbal recall task; no differences in performance on either task were detected between groups (Gunstad et al., 2008). Li, Dai, Jackson, and Zhang (2008) also used the Digit Span subtest from the WISC-R to assess working memory in a sample of 8 to 16 year old obese, overweight, and normal weight children and adolescents. Results indicated that the overweight and obese groups performed similarly to the normal weight group (Li et al., 2008). Collectively, it appears that working memory performance is not associated with increased body weight, although more research is needed to clarify this relationship.

Cognitive flexibility. Cognitive flexibility is the ability to learn a rule and subsequently shift to a new rule as the task requires it. The Trail Making Test – Part B (TMT) was used to examine cognitive flexibility in a sample of children and adolescents aged 6 to 19 years old (Gunstad et al., 2008). Groups were organized based on BMI, including underweight, normal weight, overweight, and obese. No differences were found between groups on the TMT, suggesting similar cognitive flexibility (Gunstad et al., 2008). Cserjesi et al. (2007) used the Wisconsin Card Sorting Test to assess cognitive flexibility in their sample of obese and normal weight boys (*M*age = 12.1, *SD* = 0.9). The obese group had significantly more total committed errors, perseverative responses, and perseverative errors, indicating a reduced ability to switch between sets compared to the normal weight group (Cserjesi et al., 2007). Furthermore, BMI was positively correlated with perseverative responses (Cserjesi et al., 2007). Blanco-Gomez et al. (2015) also investigated cognitive flexibility in their sample of obese, overweight, and normal weight 6 to 10 year old children. The reading and switching subscales on the FDT were used to assess flexibility. The switching subscale assesses the participant's ability to switch between task sets. Results indicated that all groups performed similarly, although flexibility was a significant predictor of overweight/obese status, indicating that it took them longer to switch between sets (Blanco-Gomez et al., 2015). Due to the limited literature, a general conclusion regarding cognitive flexibility in overweight/obese children cannot be made. However, the above studies suggest that some overweight/obese children may take longer to complete the task or may commit errors when completing the task.

Visual spatial processing. Li et al. (2008) investigated visuospatial organization in obese, overweight, and healthy weight children and adolescents aged 8 to 16 years old using the Block Design subtest from the Wechsler Intelligence Scale for Children, Revised (WISC-R). A significant association was found between increased body weight and decreased visuospatial ability, even after controlling for various confounds, including age, gender, race/ethnicity, family SES, parent education, general health status, physical activity, sports participation, blood pressure, cholesterol, and psychosocial development (Li et al., 2008). The results indicate that body weight uniquely contributes to visual spatial ability, although only Block Design was used to explain this relationship. Jansen et al. (2011) examined mental rotation performance in a sample of healthy (M*age* = 9.94, *SD* = 0.68) and overweight (M*age* = 10.00, *SD* = 0.89) children from Germany who were matched by age, gender, and SES. Results from the Chronometric Mental Rotation Test indicated that groups did not differ based on reaction time (Jansen et al., 2011). Error rates increased for both groups when the difficulty of the task increased; furthermore, error rates were significantly higher for the overweight children than normal weight children (Jansen et al., 2011). Taken together, results from the Jansen et al. (2011) study suggests the overweight group reacted to the stimuli just as quickly as did the normal weight group, but they made more errors doing so. Based on these two studies that examined visuospatial processing, it seems as though overweight and obese children may experience a deficit in this cognitive process, at least in erroneous responding, although future research is needed to help define the specific abilities involved and the relationship to body size.

Taken together, these studies of body size and cognitive functioning suggest some patterns of skills. There appears to be no significant difference between normal weight and overweight/obese children on measures of working memory (e.g., Cserjesi et al., 2007; Gunstad et al., 2008; Li et al., 2008). On measures of inhibition, overweight/obese children tend to finish the tasks at a slower rate, indicating that they may need more time to process the information in order to resist distracting stimuli (e.g., Blanco-Gomez et al., 2015; Reyes et al., 2015). The aforementioned studies are rather disparate in terms of cognitive flexibility. It appears that some children have difficulty switching between sets, and some children take longer to finish the task (e.g., Blanco-Gomez et al., 2015; Cserjesi et al., 2007). A general conclusion cannot be made about VSP and body size, based on the limited nature of the literature, but the two studies reviewed indicate that overweight/obese children exhibit more erroneous responding on VSP tasks compared to healthy weight children (e.g., Jansen et al., 2011; Li et al., 2008).

Physical Activity and Cognitive Function

Research examining the relationship between the engagement of physical activity and cognitive function in children is sparse. However, existing research has highlighted the effects of physical activity on a child's executive function, including areas such as inhibition, working memory, planning, and flexibility (e.g., Crova et al., 2014; Davis et al., 2011; Ellemberg & St-Louis-Deschenes, 2010; Kamijo et al., 2011). Other areas that were examined include attention, spatial processes, sequencing, perceptual skills, and academic achievement.

Chronic physical activity. Inhibition and working memory were assessed in a sample of lean and overweight 9 to 10 year old children from Italy before and after a 21 week physical activity intervention (Crova et al., 2014). Children in the control condition participated in a curricular PE program once a week and focused mostly on fundamental motor skills and coordination, whereas children in the experimental condition participated in the enhanced PE program, which involved one curricular PE session a week plus skills based and tennis-specific training for 2 hours weekly in order to increase cognitive demand (Crova et al., 2014). To evaluate two components of executive function (inhibition and working memory), the participants were administered the Random

Number Generation (RNG) Task. Results indicated that overweight children who participated in the enhanced PE program had a significantly greater improvement on their inhibition scores compared to the overweight children in the curricular PE program and the lean children in both conditions (Crova et al., 2014). The results were nonsignificant for working memory. Children who are overweight may benefit most from physical activity that is cognitively challenging compared to lean children and compared to curricular physical activity.

Working memory was assessed using a modified Sternberg Task in 7- and 9-year-old boys and girls, who were randomized into either a 9-month afterschool physical activity condition or the waitlist control condition (Kamijo et al., 2011). The physical activity condition involved a 2-hr session each school day including moderate to vigorous physical activity, education, and organizational games. Results indicated that the response accuracy was significantly greater at post-test compared to pre-test in the intervention group and no differences were observed in the waitlist group (Kamijo et al., 2011).

Multiple cognitive processes, including planning, attention, spatial processes, sequencing, reading, and mathematics, were evaluated using the Cognitive Assessment System and the Woodcock-Johnson Test of Achievement III by Davis et al. (2011) in a sample of overweight and inactive 7 to 11 year old boys and girls, who were randomized into either a low-dose exercise condition, high-dose exercise condition, or a no exercise condition. The intervention lasted approximately 3 months, with the low-dose condition involving physical activity (e.g., running games, jump rope, basketball) 20 minutes per day and the high-dose condition involving the same physical activity as the low-dose condition but lasting 40 minutes per day rather than 20 minutes. Results indicated that being exposed to either low- or high-dose aerobic exercise significantly increased Planning scores (Davis et al., 2011). Furthermore, a dose-response benefit was detected, indicating that the high-dose condition had a greater effect on Planning scores than the low-dose condition. A dose-response benefit also was observed on mathematics scores. Significant differences were not observed for Attention, Simultaneous, Successive, or reading (Davis et al., 2011). Taken together, this article suggests that exercise programs may have a greater impact on areas of executive function, although the impact may vary based on the duration of the intervention.

Acute physical activity. A reaction time task and choice response time task was administered to 7 and 10 year old boys who were randomly assigned to either a physical activity condition or a control condition (Ellemberg & St-Louis-Deschenes, 2010). The physical activity condition involved cycling for a total of 40 minutes, while they watched a children's show; the children in the control condition just watched the children's show. Results indicated that the children in both age groups who were in the physical activity condition exhibited significantly faster reaction times compared to the children in the control group (Ellemberg & St-Louis-Deschenes, 2010). Furthermore, both ages groups of children in the physical activity condition displayed significantly faster times on the choice response time task compared to those in the control group (Ellemberg & St-Louis-

Deschenes, 2010). Although a significant difference between conditions was not noted for performance accuracy, the results indicate the improvement in reaction time was not at the expense of accuracy.

The literature suggests that chronic and acute bouts of physical activity can improve areas of cognitive function. Cognitively challenging physical activity may be most beneficial for overweight children, as research has shown an improvement in inhibition following a 21-week program (Crova et al., 2014). Working memory also improved after a 9-month physical activity program (Kamijo et al., 2011). Planning scores improved in both high and low dose physical activity conditions after 3 months (Davis et al., 2011). Faster reaction times were observed in the acute physical activity condition compared to the control condition and performance accuracy was similar across groups (Ellemberg & St-Louis-Deschenes, 2010). Taken together, these results indicate that physical activity, short- and long-term, is beneficial to executive function.

Summary and Purpose of the Current Study

Visual spatial processing is malleable and can be improved through training (Uttal et al., 2012. This training could involve physical activity. Research also has indicated that physical activity improves frontal lobe processes, such as areas of executive function (e.g., Crova et al., 2014; Davis et al., 2011; Ellemberg & St-Louis-Deschenes, 2010; Kamijo et al., 2011). Visual spatial processing relies on right fronto-parietal functioning, suggesting a possible link between engaging in physical activity and visual spatial skills. Furthermore, the literature indicates a clear negative relationship between obesity and physical activity, with little engagement being related to higher BMI (e.g., Laurson et al., 2014; Lee et al., 2015). There also appears to be a negative relationship between obesity and some cognitive functions, with overweight/obese children showing less developed skills in inhibition, cognitive flexibility, and possibly visual spatial processing (e.g., Blanco-Gomez et al., 2015; Cserjesi et al., 2007; Jansen et al., 2011; Li et al., 2008; Reyes et al., 2015).

The purpose of the current study was to investigate the relationship between body size, physical activity and visual spatial abilities in school-aged children. We predicted that there would be a significant positive correlation between Geometric Puzzles and Arrows. It also was predicted that Arrows, a measure of visuoperception, would be significantly positively correlated with the total physical activity score. Two binary logistic regressions were conducted based on two hypotheses. It was predicted that frequency of physical activity and visuoperception (i.e., Arrows score) would significantly predict body size, with the total physical activity score entered first, then Arrows. The fourth hypothesis was exploratory. We used frequency of physical activity and Geometric Puzzles, a measure of visuoperception and mental rotation, to predict body size, with the total physical activity score entered first in the model, followed by Geometric Puzzles.

CHAPTER II

Method

Participants

The current study was part of a larger study assessing body size, physical activity, body image, and neuropsychological function in children. The total sample consisted of 16 boys and 24 girls ages 6 to 13 years who were recruited from center-based and school-based after school programs in the middle Tennessee area. Approximately 50% of the sample were Caucasian and 30% were African American. The sample was split into two groups based on body size category, with 21 children in the overweight/obese body size, 19 children in the healthy body size group, and none in the underweight category. None of the participants were excluded.

Measures

Demographics. A brief demographics questionnaire was completed by each child, asking gender, ethnicity, grade in school, etc. (see Appendix A).

Anthropometrics. Height was measured using a wall-mounted paper measuring tape to the nearest half inch. Weight was measured using a digital scale to the nearest tenth of a pound. Body mass index (BMI) was calculated by dividing the weight in pounds by the square of height in inches and multiplied by 703 [(weight in lbs/height in inches^2) x 703]. Based on the CDC calculator, children are categorized based on percentile rank of their BMI, which is determined using both age and sex. Healthy BMI is percentiles between 15th and 85th. Overweight is defined as above the 85th percentile and lower than the 95^{th} percentile. Obese is defined as 95^{th} percentile and above. The sample resulted in two classifications for this study: healthy weight and overweight/obese.

Physical activity. An exercise and physical activity questionnaire was developed to determine the types of activities children engaged in and how frequently they participated in various activities in a week's time. The questionnaire contained three main questions. The first was an open-ended question that required the child to describe what kinds of physical activity they engaged in the previous day. The second question was more structured and required the child to consider the previous week and determine if they engaged in any of the specific listed activities ("Rode my bike," "Went for a hike," "Went to PE/gym at school," etc.) and whether it was none, one or two times a week, or more than two times a week. The third question assessed whether the child participated in any group/team-based activities (e.g., basketball, cheerleading, soccer) and if so, how often he/she participated (See Appendix B). Only the second and third question were used for data analysis and were scored based on frequency. For example, no engagement in a particular physical activity resulted in a score of 0, engaging in a particular physical activity once or twice a week equaled a score of 1, and more than two times a week resulted in a score of 2. Thus, based on the number of activities assessed, the range of possible scores was 0 to 36. In the case of a participant adding an activity category to the team/organized sports question, that participation was added to the sum in the same way as those listed. This addition occurred for only one participant for one added sport.

Geometric puzzles. Geometric Puzzles (GP) is a subtest from the Visuospatial Processing domain on the Developmental NEuroPSYchological Assessment: Second Edition (NEPSY-II; Korkman, Kirk, & Kemp, 2007). This subtest was used to assess the child's ability to pay attention to detail, mental rotate images, and visuospatial analyze. The child was shown a picture of a large grid that contains multiple shapes. Two shapes on the outside match two shapes inside the grid and the child must decide which ones match by mentally rotating each shape. A total raw score was used to obtain age-corrected scaled scores on the GP. Possible scores range from 1 to 19, with higher scores indicating more advanced skills and low scores indicating difficulties with mental rotation. This measure relies mostly on right parietal lobe functioning. In terms of validity, GP is moderately correlated with Perceptual Reasoning Index on the WISC-IV (.40) and the Block Design subtest (.41). GP is normed on children ages 3 to 16 years and has an internal consistency of .75 with a normative group of children ages 7 to 12 years (Korkman et al., 2007).

Arrows. Arrows (AW) is a subtest from the Visuospatial Processing domain on the NEPSY-II (Korkman et al., 2007). This subtest was used to assess the child's ability to judge line orientation. The child is shown a picture of a target surrounded by an array of arrows. The child must determine the arrow(s) that points directly to the center of the target without using his/her finger as a guide. A total raw score was used to obtain age-corrected scaled scores on the AW. Possible scores range from 1 to 19, with higher scores indicating more advanced skills and low scores indicating difficulty with judging line orientation. This measure relies on right parietal functioning as well as some right frontal lobe functioning. AW is normed on children ages 5 to 16 years and has an internal consistency of .75 with a normative group of children ages 7 to 12 years. In terms of construct validity, AW is moderately correlated with Perceptual Reasoning Index on the WISC-IV (.44), including the Block Design subtest (.49) and Matrix Reasoning subtest (.40) (Korkman et al., 2007).

Procedure

Informed consent was gathered from all parents or legal guardians of the children in the study, and assent was obtained from each child (see Appendix C for both the consent form and assent script). The battery of tests used in the larger study was administered in a random order to minimized order effects. Only the anthropometrics, the physical activity questionnaire, GP, and AW from the larger study were used in the current study. Testing for each child lasted approximately 35 minutes, and once the battery was completed, the child received a small toy/item (e.g., pencils, bouncy balls, stickers) and the debriefing letter (See Appendix D) to take home.

CHAPTER III

Results

Descriptive Statistics

Table 1 provides information regarding the descriptive statistics for each group. The children in the overweight/obese group had an average age of 9.48 years (*SD* = 1.81) and the group consisted of 71% girls. The average age of children in the healthy group was 8.73 years (*SD* = 1.94) and the group was comprised of 47% girls. Regarding Arrows, the overweight/obese group had a mean score of 8.40 (*SD* = 3.68) and the healthy group had a mean score of 11.32 (*SD* = 2.81). The Geometric Puzzles mean score was 8.60 (*SD* = 2.16) in the overweight/obese group and 9.68 (*SD* = 3.45) in the healthy group. The groups did not differ by age, gender, or ethnicity.

Correlational Analyses

Because Geometric Designs and Arrows are both based on similar cognitive constructs and both rely somewhat on right fronto-parietal functioning, it was predicted that there would be a significant positive correlation between the two scores. In addition, physical activity and executive functioning (i.e., frontal lobe) research suggests a potential positive correlation between physical activity and Arrows (a primarily right frontal task). Pearson Product Moment correlations were calculated to test this hypothesis.

The Pearson Product Moment correlations indicated a significant positive correlation between Geometric Puzzles and Arrows. However, the predicted correlation between physical activity and Arrows failed to reach significance (see Table 2).

Regression Analyses

It was hypothesized that frequency of physical activity and visuoperception (i.e., Arrows score) would predict body size category. The physical activity questionnaire and Arrows score were used to predict group membership (healthy weight, overweight/obese) in children using a binary logistic regression. Based on the literature regarding the relationship between cognitive function, physical activity, and BMI in children, I hypothesized that both physical activity and Arrows score would be significant predictors of body size, such that more frequent physical activity and stronger visuoperceptual skills, the more likely children will have a healthy body size. The variables were entered in a stepwise fashion, with physical activity entered first, then Arrows.

A binary logistic regression was conducted with physical activity entered into the first block and Arrows entered into the second block to predict body size (see Table 3). Results for the first block were not significant for physical activity and the model was nonsignificant. When Arrows was added to the model, physical activity remained nonsignificant, but Arrows emerged as a significant predictor of body size. This block correctly classified 68.4% of overweight/obese children and 57.9% of healthy children and the model was significant.

Exploratory analysis using physical activity and visuospatial analysis (i.e., Geometric Puzzles) were conducted to test the predictability of body size category from physical activity and Geometric Puzzles. The physical activity questionnaire and Geometric Puzzles were used to predict group membership (healthy weight, overweight/obese) in children using a binary logistic regression. Due to the limited literature concerning visual spatial processing as it is related to childhood obesity and physical activity, the third analysis was exploratory in nature to assess whether visual spatial skills significantly predicted body size. The variables were entered in a stepwise fashion, with physical activity entered first, then Geometric Puzzles.

A binary logistic regression was conducted with physical activity entered into the first block and Geometric Puzzles entered into the second block to predict body size (see Table 4). Results indicated that physical activity and Geometric Puzzles were not significant predictors of body size, and the model was also not significant. The second block correctly classified 57.9% of overweight/obese children and 47.4% of healthy children.

CHAPTER IV

Discussion

The purpose of this study was to investigate the relationship between body size, physical activity, and visual-spatial processing abilities in school aged children. Three hypotheses were made. It was hypothesized that Geometric Puzzles and Arrows would be significantly positively correlated, based on their constructs relying somewhat on right fronto-parietal functioning. It also was hypothesized that Arrows would be significantly positively correlated with the physical activity score. The second hypothesis stated that both physical activity and Arrows would be significant predictors of body size, with physical activity entered into the first block and Arrows entered into the second block. Finally, the third hypothesis was exploratory, testing to see whether physical activity and Geometric Puzzles were significant predictors of body size.

There was a significant positive correlation between Geometric Puzzles and Arrows, indicating that both measures assess similar constructs. Physical activity was not significantly correlated with Arrows. Research in the field has demonstrated a relationship between executive functioning (i.e., frontal lobe) and physical activity (e.g., Crova et al., 2014; Davis et al., 2011; Ellemberg & St-Louis-Deschenes, 2010; Kamijo et al., 2011). This nonsignificant correlation suggests that Arrows (a right frontal task) taps into more than executive functioning that may not be related to physical activity. The literature also has indicated a relationship between physical activity and body size (e.g., Laurson et al., 2014; Lee et al., 2015), although the current study's results do not support this relationship. Frequency of physical activity was not a significant predictor of body size, which could be due to a methodological issue. This study used BMI to estimate body size. Although this is a generally accepted practice in health related fields, BMI does not take into account an individual's muscle mass. Thus, the relationship between physical activity and BMI may not have emerged because some who were classified as overweight/obese may have been so due to higher muscle mass and not due to high percent body fat; they may have been just as active or more active than some healthy children. Additionally, the physical activity questionnaire contained questions regarding frequency of unorganized and organized activities. The duration or intensity of these activities were not assessed. Furthermore, this was an indirect measure of physical activity, relying on the child's memory from the past week and their self-reporting rather than a direct measure of physical activity (i.e., pedometer). Perhaps a stronger relationship would have emerged if duration and intensity of physical activity was assessed, or if a direct measurement was taken.

Interestingly, visuoperceptual abilities significantly predicted body size, such that healthy children displayed greater visuoperceptual skills compared to overweight/obese children. The exploratory analysis did not reveal any significant results, indicating that Geometric Puzzles assesses a unique aspect of visual spatial processing that may not be significantly related to body size. This finding is in contrast to those in the Jansen et al. (2011) study that used the Chronometric Mental Rotation Test to assess mental rotation performance and indicated that the overweight group made more errors than healthy group. This study and the Jansen et al. (2011) study used different measures to assess mental rotation, with Geometric Puzzles being a measure of mental rotation and visuoperception.

This study provides interesting findings regarding the potential connections between visuoperception and body size. However, there are a few limitations. First of all, this study utilized a small sample size (*N* = 40) that was recruited from center-based and school-based after school programs in middle Tennessee. Many of the families who participated in the study had a lower socioeconomic status and the children in the sample had varied ethnicities. Thus, the results from this study are likely not generalizable to the entire population. Secondly, our measure of physical activity was indirect and relied on the children's account of what types of physical activity they participated in during the previous week. We asked questions related to frequency of physical activity but did not assess duration or intensity. Thus, engaging in some form of physical activity once per week could mean a duration of only 10 minutes or it could be an hour. Additionally, that same bout of activity could have been vigorous in intensity or mild to moderate. It is unclear whether frequency, duration, or intensity of physical activity best relate to body size or cognitive function; assessing these various aspects of physical activity is a clear direction for future studies. Finally, children in this study were grouped into two categories based on BMI: healthy and overweight/obese. The potential problem with classifying overweight/obese children in that manner has to do with the lack of considering body fat and/or muscle mass of the children. Two children could have the same BMI classifying them as overweight, but one child could have significantly more muscle than the other. This study did not take into account a child's muscle mass or percent body fat when categorizing them into groups.

Despite these limitations, interesting patterns emerged that indicated visuoperception is uniquely related to body size, which adds support to the limited literature concerning VSP and body size (e.g., Jansen et al., 2011; Li et al., 2008). The relationship between physical activity and obesity was not supported due to children in the overweight/obese group being just as active as those children in the healthy group. Interestingly, Geometric Puzzles was not significantly related to body size, indicating a specific set of VSP skills that may be uniquely related to body size. Future research should continue to investigate the relationship between various aspects of both VSP and physical activity, and how they relate to body shape and size in children.

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APPENDICES

APPENDIX A

Demographic Form

Demographics

Ask the child to tell you:

How old are you?

What grade are you in at school?(circle one):

1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}

What is your Ethnicity?: (circle one)

African-American	Asian/Asian-American	Caucasian
Hispanic	Native American	Other_____

Weigh and measure the child.

Height: ______________ Weight: __________________

BMI: _______________

APPENDIX B

Exercise and Physical Activity Form

<u>Exercise and Physical Activity</u>

Say to the child: ***Now I want you to think about what you have been doing today before we started talking, and about yesterday after school. What exercise or physical activities did you do today or yesterday? (If no response, suggest ideas like bike riding, played tag, played outside, played soccer, etc)***. List responses here.

Say: **Now I want you to think about the last few days, including today. I am going to say different kinds of activities and I want you to tell me about how many times you did that thing during the last week. For example, the first one is "went to PE/Gym at school. How many times did you go to Gym/PE since last (say day of week). Was it none, 1 or 2 times, or more than two times?** (Then continue with each item).

	None	1 or 2 times	More than 2 times
Went to PE/Gym at School			
Played on the playground at school			
Rode my bike			
Played outside at home			
Walked my dog			
Played Wii Sports or WiiFit			
Jumped on a trampoline			
Went for a hike			
Went for a walk with a friend or went exploring			

Say: **Some kids are on teams or participate in activities that involve some exercise on a regular basis, like once or twice a week or so. I am going to say the name of some of these activities and I want you to tell me if you are on a team or go to this kind of activity. If you do, I want you to tell me how many times a week you do it. For example, the first one is Basketball. Are you on a basketball team now?** (If "no", go on to second item. If yes, say: ***How many times a week do you practice or play with your basketball team)***

	Yes or No?	If yes, how often in a week?
Basketball		
Baseball or Tee-ball		
Cheerleading		
Dance		
Football		
Gymnastics		
Karate/Martial Arts		
Soccer		
Swimming		

APPENDIX C

Informed Consent and Assent Script

Principal Investigator: Kim Ujcich Ward, Ph.D., BCBA-D
Study Title: Children's Body Image, Physical Activity and Visual Perceptual Development
Institution: Middle Tennessee State University

Name of child: ____ Age: ___________

The following information is provided to inform you about the research project and your child's participation in it. Please read this form carefully and feel free to ask any questions you may have about this study and the information given below. You will be given an opportunity to ask questions, and your questions will be answered. Also, you will be given a copy of this consent form.

Your child's participation in this research study is voluntary. He or she is also free to withdraw from this study at any time. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study.

For additional information about giving consent or your rights as a participant in this study, please feel free to contact the MTSU Office of Compliance at (615) 494-8918.

1. **Purpose of the study:**
   Your child is being asked to participate in a research study because we are interested in learning about how children's understanding of their body shape and size may be related to how they see things and understand what they see.

2. **Description of procedures to be followed and approximate duration of the study:** The study we are doing will take your child about 30 minutes to participate. During that time, he/she will measure their height and weight. We also will ask them questions about foods they like and don't like, how they feel about their bodies, and some things they might be thinking about their bodies and health. We also will have them look at some pictures of different body shapes and sizes and have them tell us what they think of them. Finally, they will be asked to do some visual puzzles. We will be doing these things individually with each child who participates. The study will be conducted during normal ESP hours.

3. **Expected costs:** There are no costs to you or your child for him/her to participate**.**

4. **Description of the discomforts, inconveniences, and/or possible risks that can be reasonably expected as a result of participation in this study:** The risk for your child to participate in this study is minimal. Some children may be uncomfortable answering questions or talking about their thoughts and feelings about their body shape and size. If your child does not want to answer a question or do an activity that is part of the study, he/she can skip that question or that part. There will be no negative consequences if they skip something or want to stop at any point. Each child will be told this before we start the study, and will be reminded that it is ok to say you don't want to say or do something during the project.

5. **Compensation in case of study-related injury: N/A**

6. **Anticipated benefits from this study: The anticipated b**enefits from this study include a better understanding of how body image perception and satisfaction occur across different ages of young children and how these factors may be related to a child's understanding of what they see and how they interpret what they see. This kind of information may be helpful to identify early risk factors for intervention that could prevent the development of eating disorders in children.

7. **Alternative treatments available: N/A**

8. **Compensation for participation:** Each child who participates in the study will be given a small trinket/toy as a thank you for participating.

9. **Circumstances under which the Principal Investigator may withdraw you from study participation:**
If at any time during the project your child seems distressed, as may be indicated by crying, yelling, or becoming very withdrawn, we will stop the study and talk with your child to help calm them. We will then return them to their ESP class. We do not expect the children to become distressed because of the study, but if they do, we will stop their participation.

10. **What happens if you choose to withdraw from study participation:** If your child chooses to stop participating at any point during the study, he/she will still receive the small thank you trinket/toy. There will be no negative consequences to your child for choosing not to participate fully.

11. **Contact Information.** If you should have any questions about this research study or possibly injury, please feel free to contact Kim Ujcich Ward at 615-898-2188 or email Kimberly.ward@Mtsu.edu**.**

12. **Confidentiality.** All efforts, within reason, will be made to keep the personal information in your child's research record private but total privacy cannot be promised. Your information may be shared with MTSU or the government, such as the Middle Tennessee State University Institutional Review Board, Federal Government Office for Human Research Protections, *if* you or someone else is in danger or if we are required to do so by law. If during the study your child shares any information that would lead us to believe he/she is in danger or causing harm to him/herself, we will discuss our concerns with your child and will contact you (his/her parent/guardian) with that information. Please put a contact number on the bottom of this form so we can contact you if we need to do so.

14. **STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS STUDY**
I have read this informed consent document and the material contained in it has been explained to me verbally. I understand each part of the document, all my questions have been answered, and I give permission for my child to participate in the study.

____________________________ ____

Date Signature of patient/volunteer

____
Phone number or contact information for parent/guardian

Consent obtained by:

__________________ ______________________________________
Date Signature

____
Printed Name and Title

Assent Script for Body Image and Neuropsychological Functioning in Children Study

Read the following to the child:

Thank you for coming to meet with us today. We are doing a project to help us learn more about how children think about their bodies and their health. What we are doing today will be lots of different things. We will be seeing how much you weigh and how tall you are. We also will show you some pictures and drawings and ask you to tell us or show us something about them. We are going to do some puzzles and activities, too. Finally, we also will ask you some questions about things you might eat, exercise you might do, and things you might think about. These questions aren't like a test you have in school; they are more like questions about you and your ideas. If we ask you something that you don't understand, you can just say that – like, "I don't know what you are talking about!" or "I don't understand that one", and we will try to explain it to you. If we ask you something that you don't want to answer, you don't have to – just say something like, "I don't want to answer that one", or "can we please do the next one" and we will go on. You won't be in any trouble or anything if you don't answer something or if you don't want to do any of the things we ask you to do. We aren't going to tell anybody what your answers are or what you do with us today, so don't worry about if someone will find out. There is one situation when we might tell somebody, and that would be if you tell us something that shows you are harming yourself or that someone else is harming you. Then we would have to tell so that someone can help you not to be harmed.

Your parents have already said it was ok for you to help us with this project today if you want to.

Would you like to participate?

APPENDIX D

Child Debriefing Letter

Thank you for allowing your child to participate in our study about body image and functioning in elementary school age children. We hope to learn some interesting things about how the way children think about their bodies might be related to things they do and the way their brain uses different kinds of information. The kinds of questions and activities the children in the study participate in will help us to figure out this potential relationship. If you have any questions or concerns about the study or your child's participation in the study, please contact me (Kim Ujcich Ward) at 615-898-2188 or email Kimberly.ward@mtsu.edu

If after participating in the study your child has concerns about his/her body image, eating behaviors or health habits, or if you have concerns about your child, the following resources have professionals who might be able to help you and your child. Feel free to contact any of these service providers directly should you want help with body image or eating-disorder-related problems.

Murfreesboro City Schools Office of Coordinated School Health
Contact: Meri-Leigh.Smith@cityschools.net

The Guidance Center/Volunteer Behavioral
118 North Church Street
Murfreesboro TN 37130
Phone: (615) 893-0771 or 890-4622

Your child's school also has a guidance counselor on staff who can assist with helping your child with these issues.

APPENDIX E

Tables

Table 1

Descriptive statistics for full sample and by body size category

	Total Sample		Overweight/Obese*		Healthy*	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	9.13	1.88	9.48	1.81	8.73	1.94
Arrows**	9.82	3.56	8.40	3.68	11.32	2.81
Geometric Puzzles**	9.13	2.88	8.60	2.16	9.68	3.45
Physical Activity	9.37	4.00	9.68	4.23	9.05	3.85
BMI	20.43	4.00	23.13	3.62	17.45	1.47
BMI Percentile	77.60	19.42	90.52	14.27	63.32	13.49

Note. Age range is from 6-13 years. BMI calculated using formula (weight/height^2) x 703.
*Overweight/Obese: n = 21; Healthy: n = 19
**Standard scores, M = 10 and SD = 3

Table 2

Correlations between visual spatial processing and physical activity

	Geometric Puzzles	Arrows
Geometric Puzzles	—	—
Arrows	.552*	—
Physical Activity	-.054	.105

*$p < .001$

Table 3

Binary logistic regression comparing overweight/obese (n = 21) to healthy children (n = 19) predicted by Arrows

Block #1 Predictor: Physical Activity

Independent Variable	B	S.E.	Wald	Sig.	Exp(B)
Physical Activity	-0.041	0.083	0.241	.623	0.960
Model χ^2 =	0.244	p = .622			
Pseudo R^2 =	.009				
n =	38				

Classification Table for Block #1

	Predicted Group			
Observed Group	Overweight/Obese	Healthy	Total	Percentage Correct
Overweight/Obese	10	9	19	52.6%
Healthy	9	10	19	52.6%
Overall				52.6%

Block #2 Predictor: Arrows

Independent Variable	B	S.E.	Wald	Sig.	Exp(B)
Physical Activity	-0.074	0.093	0.629	.428	0.929
Arrows	0.290	0.126	5.265	.022	1.336
Model χ^2 =	6.806	p = .033			
Pseudo R^2 =	.219				
n =	38				

Classification Table for Block #2

	Predicted Group			
Observed Group	Overweight/Obese	Healthy	Total	Percentage Correct
Overweight/Obese	13	6	19	68.4%
Healthy	8	11	19	57.9%
Overall				63.2%

Table 4

Binary logistic regression comparing overweight/obese (n = 21) to healthy children (n = 19) predicted by Geometric Puzzles

Block #1 Predictor: Physical Activity

Independent Variable	B	S.E.	Wald	Sig.	Exp(B)
Physical Activity	-0.041	0.083	0.241	.623	0.960
Model χ^2 =	0.244	p = .622			
Pseudo R^2 =	.009				
n =	38				

Classification Table for Block #1

	Predicted Group			
Observed Group	Overweight/Obese	Healthy	Total	Percentage Correct
Overweight/Obese	10	9	19	52.6%
Healthy	9	10	19	52.6%
Overall				52.6%

Block #2 Predictor: Geometric Puzzles

Independent Variable	B	S.E.	Wald	Sig.	Exp(B)
Physical Activity	-0.039	0.085	0.211	.646	0.962
Geometric Puzzles	0.134	0.123	1.186	.276	1.144
Model χ^2 =	1.518	p = .468			
Pseudo R^2 =	.052				
n =	38				

Classification Table for Block #2

	Predicted Group			
Observed Group	Overweight/Obese	Healthy	Total	Percentage Correct
Overweight/Obese	11	8	19	57.9%
Healthy	10	9	19	47.4%
Overall				52.6%

APPENDIX F

MTSU IRB Approval Letter

5/7/2015
Investigator: Kimberly J. Ulcich Ward
Department: Psychology
Investigator Email: Kimberly.Ward@mtsu.edu
Protocol Title: Children's body image, physical activity, and visual perceptual functioning
Protocol Number: 14-347

Dear Investigator(s),
I have reviewed your research proposal identified above and your request for continuation. Approval for continuation is granted for one (1) year from the date of this letter. Any changes to the originally approved protocol must be provided to and approved by the research compliance office.You will need to submit an end-of-project report to the Office of Compliance upon completion of your research. Should the research not be complete by the **expiration date, 5/2/2016**, please submit a Progress Report for continued review prior to the expiration date.

According to MTSU Policies, a researcher is defined as anyone who works with data or has contact with participants. Therefore, should **any individuals be added to the protocol that would constitute them as being a researcher, ensure that they have taken the correct training and inform the Office of Compliance prior to their involvement on the project**.

Any change to the protocol must be submitted to the IRB before implementing this change. Please note that any unanticipated harms to subjects or adverse events must be reported to the Office of Compliance at (615) 494-8918. Also, all research materials must be retained in a secure location by the PI or **faculty advisor (if the PI is a student) for at least three (3) years** after study completion. Should you have any questions or need additional information, please do not hesitate to contact me.

Sincerely,
Research Compliance Office
494-8918
Compliance@mtsu.edu