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Reasoning Abilities and Potential Correlates Among Jordanian School Children

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Abstract
Objectives To investigate factors related to reasoning skills in 434 school children aged 5–9 years. *Methods* The Leiter International Performance Scale-Revised was used to assess reasoning skills. Demographic, work and family income data, information on child's daily behavior and school academic achievement were provided by the participating children's parents. *Results* Reasoning scores increased by 4.56 points with increasing subject's age, 1.71 points with increasing level of father's occupation, 1.86 points with each increase in the subject's GPA, 1.13 points with consumption of breakfast at home and 1.81 points when child slept more hours. Having a father who smoked and living in a rural area decreased scores in reasoning. *Conclusions for Practice* Screening of reasoning and associated factors is essential for a comprehensive and accurate understanding of the child's abilities and limitations. Understanding the child's reasoning abilities is critical for establishing intervention goals and planning therapeutic activities.

Keywords Leiter International Performance Scale-Revised (Leiter-R) · Reasoning abilities · Therapists · Interventions · Sociodemographic factors · Academic performance

Significance

Reasoning skills represent an interaction between different factors such as culture, environment, and sociodemographic status. Such factors affect the amount of care, training, and opportunities given to children and understanding these interactions may assist therapists and other professionals in screening and assessing reasoning skills, understanding a child's abilities and limitations, and establishing intervention goals and strategies. Early detection of reasoning problems in children is essential for academic and occupational success later in life.

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Introduction

Cognitive abilities and skills such as reasoning, memory, attention, visualization, as well as perceptual functioning directly influence and enable the performance of tasks of varying complexity (Fourneret and Des Portes 2016; Richland and Burchinal 2013). Reasoning, one of the most important cognitive skills, is the process of making new decisions and drawing new conclusions through intellectualization and synthesizing information about events, situations, or ideas (Tepeli 2012). Such skills help individuals to understand the truth and its meaning by accurately deducing situations that can be clearly proven (Cirino et al. 2016). Reasoning skills ease problem-solving among children through establishment of cause and effect, making new inferences, and the generation of novel ideas. In addition, reasoning enables children to acquire and practice necessary knowledge and skills, as well as the improvement of their creativity and productivity

(Garder 1993). As a result, it is important to identify the variables that influence the reasoning skills of school-aged children. Therefore, the purpose of this study is to determine whether age, gender, sociodemographic variables and other parent-related factors predict reasoning skills or not in normally developing school-aged children.

Several factors influence a child's general cognitive abilities and performance and the interaction among people, activities, and environment. However, the findings of these studies which have described the correlates of general cognitive skills during childhood suggest a need for further investigation of the subject and to broaden the research to other cultures. Some of these factors include age and gender (Vera-Estay et al. 2016; Elosua and Mujika 2015; Herrmann et al. 2013; Diaz-Morales and Escribano 2013; Tepeli 2012), socioeconomic status, parents' education and occupation and adult–child's interaction (Vera-Estay et al. 2016; Thompson and Foster 2014; Sriram and Sandhu 2013; Schady 2011), school setting and area of residence and cultural differences (Wang et al. 2016; Yongtao et al. 2016; Midouhas and Flouri 2015; Meeno 2013), nicotine exposure (Ramsay et al. 2016; De Alwis et al. 2015; Park et al. 2014), child' birth order among siblings, and culture (Weimer and Gasquoine 2016; Schuhmacher and Kartner 2016; Kennedy et al. 2015; McAlister and Peterson 2013). These factors are likely to reflect typical Western child-rearing practices as well as an opportunity for cognitive stimulation through engagement with the environment including social interactions (parent–child relations) and experiences (e.g. sports, music lessons, etc.). In the present study, we examined the association of these same factors to cognitive abilities in children from Middle-Eastern cultures. Similarly, we expect that different cultures have unique parenting practices that differently affect children's development, behaviors, skills, and cognitive abilities (Riggs and Toung 2016; Unsworth et al. 2012). The authors hypothesized that predictors of general cognitive skills are different to those of reasoning skills. Furthermore, most of these research examined the effect of these factors on general cognitive abilities and not on reasoning abilities, where correlates of reasoning have not yet been studied. Hence, further research in this specific area is warranted.

Reasoning capabilities and use of information processing vary among children and such differences can affect both learning and academic performance (Barrigas and Fragoso 2012; Richland and Burchinal 2013; Habibullah and Ashraf 2013; Berninger and Abbott 2013). Reasoning abilities have been found to affect mathematics and reading skills, skills which could be reinforced, and predict academic success (Cirino et al. 2016; De Chantal and Markovits 2016; Resing et al. 2012). As a result, assessment of children's reasoning abilities can identify problems that may affect school performance (Green et al. 2014; Dumontheil and Klingberg 2012). Furthermore, early detection of high risk and special needs among children can enable early intervention implementation and influence future social and vocational and occupational aspects of adult life (Schaffer and Geva 2016).

Assessing cognitive abilities outside of Western cultures presents a particular challenge. Although, there are several standardized screening instruments for cognitive abilities (i.e. memory, attention, reasoning, visualization, etc.), including the Battery of Reasoning Tests 5 (BPR-5) (Primi et al. 2013), the Inductive Reasoning Test for Children (Muniz et al. 2011); the Dynamic Testing of Analogical Reasoning (Stevenson 2013), the Test of Auditory Reasoning and Processing Skills (Garder 1993), the Perceptual Reasoning Index (PRI) (Dowell and Mahone 2003), and the Spanish Reasoning Test (Elosua and Mujika 2015), these instruments have not been validated in Arabic speaking populations. An alternative to these instruments is the Leiter International Performance Scale-Revised (Leiter-R). The Leiter International Performance Scale-Revised (Leiter-R; Roid and Miller 2002), a cognitive screening battery used in children and adolescents aged 2–20 years, was developed for the purpose of conducting a comprehensive, nonverbal diagnostic assessment to measure increments of improvement in different cognitive skills, early assessment of cognitive delays, and to serve as a reliable and valid scale of intelligence regardless of language or motor ability. The instrument has been shown to be valid and reliable, with internal consistency (Alpha) reliability coefficients of 0.89–0.91% for the reasoning battery and 0.76–0.88 for the memory and attention battery (Hooper and Bell 2006; Roid and Miller 2002). The Leiter-R subtests for reasoning were chosen for their psychometric properties and primarily non-verbal nature, thus making them a better potential fit for individuals from non-Western and non-English speaking cultures, including Jordan.

Method

Design

This study used a descriptive, cross-sectional, correlational design.

Participants

By contacting the Jordanian ministry of education, principal investigators obtained a list of all public and private elementary schools in the north of Jordan (140 public schools and 148 private schools) that include children with an age range of 5–9 years. Principal investigators used a multistage sampling technique to select schools randomly from a complete list of eligible schools (i.e. elementary schools which include children aged 5–9 years) stratified

by gender and type of school and district. Then, investigators randomly selected classes from each recruited school and took the whole students within each class. The current study enrolled 434 randomly selected children. The inclusion criteria included normal development, an age range of 5–9 years, and regular school attendance at a private or public school. Exclusion criteria included diagnosis of a learning, developmental, or neurological disability, as reported by teachers and/or parents. For the purpose of student recruitment, a total of 550 information packages were randomly distributed to school children a day prior to the data collection. Of the 550 packages, only 70 (13%) recipients (parents) refused to participate and 46 (8%) children were not eligible due exclusion criteria.

The information packages included information sheet describing the study purpose and procedure in details, parental consent form, that needed to be signed if the child is eligible and the parents voluntarily accepted their child to participate, and parental self-reporting questionnaire that has demographics and other required information.

The level of father's occupation was defined in the current study as (i.e. not employed or employed (military, hand maker, administrative [secretary, managers, supervisors, etc.] and profession [physicians, teachers, engineers, etc.]). In the current study, regular consumption of breakfast means having breakfast every morning at home before going to school.

Procedure

The current study was approved by the Institutional Review Boards at King Abdullah University Hospital, Deanship of Scientific Research at Jordan University of Science and Technology in Jordan, and the Jordanian Ministry of Education and relevant educational districts. Signed, written parental consent was sought and provided prior to study commencement. The Leiter International Performance Scale-Revised (Leiter-R) was used to screen the participating children's cognitive abilities. Trained research assistants (occupational therapists) received intensive training by the lead investigator (Associate Professor of occupational therapy) on the data collection process, as well as the administration and scoring system of the Leiter-R Battery. Inter-rater reliability was maintained by assessing and scoring 20 schoolchildren (10 boys and 10 girls aged 5–9 years) until 98% compatibility of the findings was reached between the principal investigator and the research assistants. The evaluation of the participating children was conducted in the school in a quiet room, during regular school hours, excluding recess hours, and lasted an average of 60–90 min (M = 75, SD = 12.4).

Instrument

The Leiter International Performance Scale-Revised (Leiter-R) (Roid and Miller 2002) was used to assess the cognitive abilities of children including memory, attention, visualization, and reasoning. The scale, designed specifically for children who speak English as a second language and for those with communication, hearing, and motor impairments, contains two subscales of 20 items each: (A) the visualization and reasoning (VR) subscale with ten items related to nonverbal intellectual ability including visualization, reasoning and spatial ability, and (B) the attention and memory (AM) subscale with ten items related to nonverbal attention and memory function (Roid and Miller 2002). The visualization subtests include; figure ground test (FG), Figure Rotation (FR), Form Completion tests (FC), Matching tests (M), Picture Context tests (PC), and Paper Folding Tests (PF). The reasoning subtests include; Repeated Patterns (RP), Classification tests (C), Design analogies test (DA), and Sequential Order tests (SO). The memory subtests include; Association Pairs (AP), Immediate Recognition (IR), Forward Memory (FM), Reverse Memory (RM), Visual Coding (VC), Spatial Memory (SM), Delayed Pairs (DP), Delayed Recognition (DR). The attention subtests include Attention Sustained (AS) and Attention Divided (AD). For the purpose of this study, only the participants' scores in reasoning subscale were analyzed. The researchers did not necessarily administer all items of a specific subtest at all ages as suggested by the developer of the Battery. For example, for 6–10 years we can only administered FG, DA, FC, M, SO, RP, PF subtests from the VR battery and AP, IR, FM, AS, RM, VC, SM, DP, DR, and AD subtests from the AM battery. Less number of items can be administered for younger ages and more items for older ages (Roid and Miller 2002).

A composite score for each of the Leiter-R's two batteries was calculated by totaling the scores of the relevant items. The maximum score on the VR battery equals a hundred (SD = 15). The maximum score for the AM battery equals a hundred (SD = 15). A higher score indicates better cognitive performance. Raw scores were used in this study, as the Leiter-R battery scores have not yet been standardized for Jordanian children.

Instrument Translation

The Leiter-R battery manual was translated into Arabic by five expert bilingual university professors from Jordan, Saudi Arabia, and Qatar using a backward-forward translation process (Brislin 1980). The authors used the same method of translating and standardizing the Lowenstein Occupational Therapy Cognitive Assessment (Al-Sheyab et al. 2014) and Adolescent/Adult Sensory Profile (Almomani et al. 2013). Discrepancies in the translation of certain

items were discussed until a consensus was reached and a pilot study with 20 children was conducted in order to evaluate the clarity and readability of the initial versions of the translated battery; the items were then modified accordingly and revised version was administered to 20 other children. Then, researchers unanimously agreed that no further modification was required. This translated Arabic version of the instrument was then back translated into English by a bilingual native English and fluent Arabic speaker who was unfamiliar with the original versions of the instrument. Thereafter, this process of backward translation was evaluated by ten expert bilingual university professors.

The scores of the instrument in evaluating the translation, which are different from the reasoning scores, ranged from 0 (not similar) to 1 (similar) and a cut score of at least 0.80 was identified in order to assess the adequacy of the Arabic translated version, which implies that 80% or more of the evaluators agreed that the backward translated item had the same meaning as the original item. A score below 0.80 suggested a possible problem with the translation. After the translation stage was completed and modifications were attended, all translated items achieved the cut off score of 0.80.

Data Processing and Statistical Analyses

Data was analyzed using SPSS Version 20 (SPSS 2012) after the cleaning and coding process; descriptive statistics (M and SD) were conducted to describe the participants' reasoning abilities using the battery as well as their sociodemographic characteristics.

Multivariate linear regression model analysis was also conducted to assess the relationship of reasoning abilities with several relevant factors related to participating children including: age of the child, order of the child among siblings in the family (i.e. first child, second child, etc.), breakfast habit (i.e. daily consumption of breakfast before school), place of residency (i.e. if the child lives in urban (cities) or rural (town or village) areas, number of child's daily sleeping hours, academic grade point average (GPA), smoking behavior of the father and mother (parent defined as smoker if he/she has smoked > 10 cigarettes/day indoors for > 5 years), occupation of the father and mother; not employed or employed [military, hand maker, administrative (secretary, managers, supervisors, etc) or profession (physicians, teachers, engineers, etc.)], level of education of the father and mother (i.e. less than high school, high school, 2 years college, bachelor degree or graduate degree) and total annual salary of the family in Jordanian Dinar. All related variables were entered into the model using the backward elimination method. Significance was set at the probability level of P = 0.05.

Results

The sociodemographic characteristics of the sample are presented in Table 1. The age range of the 434 children enrolled in the study was 5–9 years, with a mean age of 8.16 years (SD = 1.9). There were higher proportion girls (57%) and students in urban (54%), with approximately similar proportions in public vs. private schools (49% in private schools). The majority of the children in the current study reside with both parents (98%), and 51% of parents reported a family income of less than 6000 Jordan Dinar per year. The average annual family income of Jordanian families is 3663 Jordanian Dinar. Over half of the children (59%) reported eating a regular breakfast at home before school, 64% slept 9 h or more daily, and 60% reported a GPA in school of 80 or better. The GPA score ranges from (35–100); a score of less than 50 is considered a failure and a score of 90–100 is considered to be excellent.

Table 1 Socio-demographic and personal data for study sample (N = 434)

Variable	N (%)
Age (years)	
5–6.5	253 (58)
6.6–9	181 (41)
Mean ± SD	8.16 ± 1.9
Gender	
Male	189 (43)
Female	245 (57)
Area of living	
Urban	236 (54)
Rural	198 (46)
School type	
Public	214 (49)
Students live with both parents	
Yes	427 (98)
Student's GPA	
50–69	69 (16)
70–89	231 (53)
90–100	133 (31)
Family yearly income (Jordan Dinar)	
< 6000	223 (51)
6000–12,000	120 (28)
12,000–24,000	52 (12)
> 24,000	39 (9)
Child takes breakfast at home	
Yes	254 (59)
Daily sleeping hours	
≥ 9 h	276 (64)
< 9 h	158 (36)

Table 2 illustrates that approximately two-thirds (65%) of mothers were not employed whereas only 6% of fathers were not employed. Working in administrative occupations (secretary, managers, supervisors, etc.) were the most common jobs for working fathers (26%) and mothers (13%). About one-third (33.3%) of the mothers reported only a high school education and more fathers (41%) reported having bachelor's degree. Furthermore, about 5% of mothers and 62% of fathers were smokers (defined as having smoked > 10 cigarettes/day indoors for > 5 years).

Table 3 shows the average scores of the Leiter-R reasoning battery, based on children's age. The average score of 28.87 (SD = 6.87) was the lowest for ages 5–5.9 years. The highest average score was 45.56 (SD = 10.43) for ages 8–9 years. These scores reflect reasoning skills, as per the original Leiter-R battery.

The regression test with predictor variables of reasoning subtests is shown on Table 4. The following variables were considered to be predictor variables of the reasoning subtests and explained 27.4% of the variance (R = 0.523) (df = 28) (St error = 9.229): subject's age, subject's GPA, subject's eating breakfast at home, subject's daily sleeping hours, father's occupation, father's smoking, and area of residence. The mean total reasoning skills score increased by 4.56 points for each increase in the subject's age by 1 year, 1.858 points with 10 points increase in subject's GPA, 1.71 points with increase in level of father's occupation (i.e. not employed or employed (military, hand maker, administrative [secretary, managers, supervisors, etc.] and profession [physicians, teachers, engineers, etc.]), 1.13 point with regular consumption of breakfast every morning at home before going to school, and 1.8 points when the subject slept more hours daily. By contrast, the mean total score of reasoning skills decreased by 3.11 points if the subject lives in rural areas, and 1.81 points if the subject's father smoked inside the home > 10 cigarettes/day indoors for > 5 years.

Table 2 Parents' variables for study sample (N = 434)

Variable	N (%)
Mother's occupation	
Not employed	282 (65)
Employed	
Military	19 (4)
Hand-maker	26 (6)
Administration	55 (13)
Profession	52 (12)
Mother's level of education	
<High school	69 (14.7)
High school	156 (33.3)
2-years diploma	74 (15.8)
Bachelor	106 (22.6)
Graduate degree	63 (13.5)
Father's occupation	
Not employed	28 (6)
Employed	
Military	107 (25)
Hand-maker	85 (20)
Administrative	113 (26)
Profession	101 (23)
Father's level of education	
<High school	60 (14)
High school	87 (20)
2-years diploma	29 (7)
Bachelor	178 (41)
Graduate degree	80 (18)
Mother's smoking	
Yes	21 (5)
Father's smoking	
Yes	271 (62)

Table 3 Leiter-R scores average (SD) in reasoning by subjects' age groups

Age groups (years)	Reasoning score Mean (SD)
5–5.9	39.24 (9.36)
6–6.9	46.73 (9.56)
7–7.9	49.76 (10.79)
8–9	51.98 (10.84)

Discussion

The results of the current study showed that various factors significantly contribute to reasoning skills. These factors include: child's age, child's GPA, child's daily sleeping

Table 4 Predictors of reasoning abilities (n = 434)

Visualization and reasoning battery	$R^2 = 0.274$			
Independent variables[a]	B	T-value	Beta	Significance
Family area of living (rural)	−3.11	−4.31	0.337	0.001
Child's age (years)	4.56	3.81	0.286	0.006
Father's occupation	1.71	2.40	0.238	0.031
Child's eating breakfast at home	1.13	2.34	0.280	0.027
Child's GPA	1.858	2.211	0.168	0.050
Child's daily sleeping hours	1.808	3.040	0.372	0.000
Father's smoking	−1.81	−5.31	0.463	0.000

[a]Included variables (all variables): child's age, child's gender, family area of residence, child's type of school, child lives with both parents, child's birth order among siblings, mother's occupation, mother's education, father's occupation, father's education, family annual income, child's GPA, child's daily sleeping hours, mother's smoking, father's smoking, and child's eating breakfast at home before school

hours, eating breakfast at home before going to school, father's level of occupation, father's smoking status, and family area of residence. Conversely, family yearly income, mother's occupation, parent's education, type of school, and birth order among siblings were not found to be significantly related to the reasoning skills of the study sample.

Child's Age and Gender

Older children were found to achieve higher scores in reasoning subtests and no gender differences were identified, which is consistent with previous research findings (Vera-Estay et al. 2016; Herrmann et al. 2013; Diaz-Morales and Escribano 2015; Tepeli 2012). For example, a researcher worked with forty-five 5.8–11 year old Canadian children found that the reasoning skills of children increase as they grow up and do not change based upon gender (Tepeli 2012). Similarly, The examination of 86 Chinese children showed rapid growth of reasoning skills between ages 4–5 years, with no difference between girls and boys; however, the study indicated that cultural factors may influence reasoning skills among children (Hong et al. 2005).

More recent research has shown differences in reasoning and other cognitive skills between boys and girls (Li et al. 2016; Liu et al. 2015; Ramsay et al. 2016). For example, one study assessed gender differences in intellectual function among a group of 1744 school-aged children (aged 7–10 years) in rural China and found that boys scored significantly higher than girls in perceptual reasoning index scores (Li et al. 2016). Further research need to include a comparison of rural and urban areas among different cultures.

Child's GPA

The current study found that children with a higher GPA score are higher in reasoning skills, a finding supported by previous research. It has been found that reasoning skills may be directly related to academic success and school performance and could be influenced by external factors (Pasnak et al. 2015; Thuneberg et al. 2014, 2015; Diaz-Morales and Escribano 2015; Barkl et al. 2012). Thuneberg et al. (2015) investigated the relationship between reasoning skills and academic achievement in a group of 769 students aged 15 years from seven different schools in Eastern Finland. A positive relationship was found between reasoning and school achievement, a result which differed from one class to another, suggesting that class composition and school facilities also affect reasoning and school achievement. Improving other cognitive abilities and skills through cognitive training programs, such as sequencing and visualization, could positively influence inductive and deductive reasoning skills, thereby affecting class room learning and achievement in early education (Pasnak et al. 2015; Barkl et al. 2012). Future research focusing on testing the long term effect of cognitive training programs in different school settings and potential motivational/correlated variables is warranted.

Child's Sleeping Hours

The current study found a significant direct relationship between reasoning scores and number of daily sleeping hours. There is accumulating evidence that sleep quantity and quality influence cognitive abilities, including reasoning in school aged children (Diaz-Morales and Escribano 2015, 2013; Doucette et al. 2015; Vaughn et al. 2015; Bruni et al. 2012; Gruber et al. 2010; Quach et al. 2009). Gruber et al. (2010) measured the cognitive function and sleeping behaviors of 39 normally developing school children, aged 7–11 years and found that longer habitual sleep duration was associated with better academic performance as well as better reasoning and overall IQ, as measured by WISC tests, even in the absence of sleep deprivation. Similarly, an analysis of the sleep macrostructure of 42 children aged 7.6 years with socioeconomic status reflecting national norms found that sleep quality was a significant predictor of reasoning skills, as measured by the Stanford Binet Intelligence Scale (Bruni et al. 2012). Sleep has also been found to affect the speed of executive cognitive operations in preschool children as well as adaptive functioning and behaviors (Doucette et al. 2015; Vaughn et al. 2015). Therefore, number of sleeping hours and quality of sleep are directly associated with the general cognitive abilities and academic success of school-aged children. Sleep intervention programs for children are recommended and may reduce the impact of sleep problems. Unfortunately, there is no published data available in Jordan about children's sleep habits or any suggested sleep intervention programs. Further research is required in this area.

Child's Birth Order

Neither child birth order or number of siblings was found to be correlated with reasoning skills in the study population, however, a number of previous studies found them to be significant (Weimer and Gasquoine 2016; Schuhmacher and Kartner 2016; Kennedy et al. 2015; McAlister and Peterson 2013). Children with more older siblings or with more same sex siblings have been found more likely to benefit from each other and demonstrate better executive functions and stronger reasoning skills (Kennedy et al. 2015). This study found no difference according to this variable, finding that may be attributed to the fact that previous research studied very young children, preschoolers and infants, and this study investigated older children who already interacted and learned from other children at schools and day cares.

Eating Breakfast

Consumption of a healthy breakfast is known to be very important for children's health and well-being (Lopez-Sobaler et al. 2003). The alleviation of short term hunger has been shown to positively affect information processing, and academic participation (Rampersaud et al. 2005). Previous research provides compelling evidence that malnutrition, which is associated with skipping breakfast in children (Barr et al. 2014), has detrimental effect on reasoning skills, children's behaviors, and academic performance, deprives the brain of essential nutrients and even undermines later adult productivity (Adolphus et al. 2015; Hisam et al. 2015; Pandey et al. 2013; Marquez et al. 2001). Basch (2011) found that participation in the school breakfast program among urban minority youth had a positive impact on reasoning, academic achievement, and school absenteeism (Basch 2011). Similarly, a repeated measures clinical trial of 128 children aged 8–10 years found differences between breakfast consumption and fasting for all of the administered cognitive abilities' measures (Iovino et al. 2017). A systematic review of 15 mostly experimental studies, of short duration and limited number of subjects performed in well-nourished children found that the beneficial effect of breakfast on cognitive performance including reasoning skills appears to be emerging (Ogden et al. 2014). Such findings may raise the awareness of parents regarding the importance of providing a regular breakfast for their school-aged children as well as the consequences of poor nutritional intake. Furthermore, in the current study, 41% do not eat daily breakfast at home before going to school. This is considered a broad problem given that Jordanian schools (private and public) do not provide breakfast for their students. Therefore, school breakfast programs are totally warranted and should be recommended for the Jordanian ministry of education.

Parental Occupation

Reasoning skills were found to be improved with increase in paternal occupation level. As such, the child of a medical doctor father (profession) would be expected to present better reasoning skills than the child of a hand-maker. Previous research has shown a direct relationship between parental occupation and general cognitive abilities in children as was linked with the overall socioeconomic status of the family (Thompson and Foster 2014; Hackman et al. 2014; Sriram and Sandhu 2013; Bosmans et al. 2013; Schady 2011). According to Jordanian culture, higher level of father's occupation is associated with a higher level of education and a greater likelihood of higher maternal occupation and education level. A previous study found that lower parental education level was associated with worse cognitive performance among children aged 10–13 years. Similarly, another large longitudinal cohort study found that parental completion of high school was a strong predictor of the cognitive development of young children (Schady 2011). In addition, Bosmans et al. (2013) found that parental occupation affects the parent–child communication style which in turn, affects various cognitive abilities in children. In the current study, 6% of the fathers and the majority of mothers were not employed, therefore, programs and policies that could boost employments for Jordanian parents are highly recommended, as well as programs seeking early intervention and stimulation, through parenting programs and high-quality care centers hold promises for improving cognitive and reasoning abilities among disadvantaged children.

Parent's Smoking

This study showed that children of fathers who smoked had significantly lower scores in reasoning than children of non-smoking fathers. There was no difference in children's reasoning if the mother was a smoker, mainly because the majority of the mothers in the study reported that they did not smoke, which is to be expected in Jordanian culture, where women tend not to report being smokers as the practice is socially unacceptable. There is increasing evidence that supports the negative association between nicotine exposure and children's cognitive abilities and academic performance (Ramsay et al. 2016; De Alwis et al. 2015; Park et al. 2014). A comprehensive longitudinal study of a group of 54 children aged 4–6 years found that exposure to second hand smoke was negatively associated with non-verbal reasoning skills, after adjustment for sociodemographic variables and parents education (De Alwis et al. 2015). A cross sectional analysis of the urinary cotinine (nicotine metabolites) concentrations of 996 children aged 8–11 years from South Korea, after adjusting of sociodemographic and developmental variables, found that cotinine concentrations were inversely associated with full scale IQ score (Park et al. 2014). Similarly, a study of 471 individuals, from the general population-based Northern Finland 1986 Birth Cohort, followed up from pregnancy and birth to early adulthood, found that prenatal maternal nicotine exposure was negatively associated with reasoning skills in males (Ramsay et al. 2016). Moreover, smoking is a huge health burden among Jordanian population. Jordan has the most prevalent rate of males smoking in the Middle East (Bader et al. 2017). A recent national study of boys in grades 7 and 8 from four randomly selected high schools in the city of Irbid found that the overall prevalence of ever having smoked a cigarette was 35.6% (Al-sheyab et al. 2014). Almost half of the sample reported waterpipe/shisha use and the most common age in which Jordanian adolescents started to experiment with cigarettes was 11–12 years old (49.1%), although 10 years was also

common (25.3%) (Al-sheyab et al. 2014). In another large national survey with a total of 2,407 adolescents of both sexes, 57.6% consumed tobacco and 30% reported dual smoking (cigarettes and waterpipe) (Alomari and Al-sheyab 2017). In the current study, 65% of fathers were smokers. Therefore, parents need to be educated about the harmful effect of second hand smoke on children and smoking prevention and cessation programs are urgently needed among the Jordanian population to protect children's development.

Area of Residence and Type of School

This study showed that children living in urban areas had better reasoning skills scores than children living in rural areas and no difference was found between children who attended public or private school. While several studies have found similar results (Wang et al. 2016; Yongtao et al. 2016; Midouhas and Flouri 2015; Meeno 2013), others have not reported such an association (Zahrou et al. 2016; Penkunas and Coss 2013; Norman 1980). In two standardized reasoning tests used to assess the intelligence of a nationally representative sample of school aged children from China, the urban sample was found to perform better than rural sample (Wang et al. 2016). The UK's Millennium Cohort Study also found, after adjustment for different factors, that different cognitive abilities were better for children living in urban areas than living in rural areas at age 7 years (Midouhas and Flouri 2015). These study results could be attributed to the fact that most educated parents with higher socioeconomic status prefer to live in urban areas where better quality of life and schooling systems and variable facilities are more available. As such, further research is needed to test the effect of this variable (i.e. area of residence) and adjust for other correlating factors affecting reasoning skills in school children.

In addition, the lack of difference between public and private school children could be explained by the fact that most public and private schools in Jordan teach the same elementary school curricula, as defined by the Ministry of Education. Children in private schools are typically from families with good socioeconomic status, with working mothers who may spend less time teaching their children. Conversely, children in public schools are usually from families with fair to low socioeconomic status with non-working mothers who may spend more time teaching their children and thus positively affect their cognitive functioning.

Family Annual Income

While some research has found a link between socioeconomic status and cognitive abilities (Vera-Estay et al. 2016; Quinn 2015; Mistry et al. 2015; Chowdhury and Ghosh 2011; Byrne and Watkins 2003), others have not reported such an association (Weimer and Gasquoine 2016; Tepeli 2012; Chowdhury and Ghosh 2011). In the current study, neither family income nor parental education were associated with children's reasoning skills. This discrepancy in results may be due to population differences and relatively similar levels of socioeconomic status in the current sample. For instance, some research has focusing on the effect of socioeconomic status on cognitive functioning in general without discriminating between different cognitive abilities such as reasoning, attention, memory, and visualization (Piccolo et al. 2016; Hamid et al. 2011; Al-Mekhlafi et al. 2011). These studies also focused mainly on older children which that could have affected the results (Piccolo et al. 2016). Additionally, methodological differences could explain such study results. Parental education is known to be linked to children's academic performance and school success (Hooper and Bell 2006), yet the Leiter-R battery was designed to remove the need for reading, writing, and talking, therefore potentially eliminate the association between parental education and reasoning skills. Moreover, most of the study sample had at least high school education, which may have off-set the adverse effect of low family income. Thus, there is a significant difference in the number of children in the high versus low-moderate socioeconomic status categories. Previous studies explored the effect of socioeconomic status in general (e.g. type of school, parents' occupation and education, neighborhoods, etc.) and not the specific effect of family annual income like the present study. In Jordan, some children may live in a prestigious neighborhood with highly educated but unemployed parents, in very good housing, attend very good governmental schools and have low annual family income, due to family dependence on grandparents for financial support. Further studies with larger samples and larger family income variations may help to clarify the precise role of parental education and income on reasoning skills in Jordanian children.

Limitations

Regardless of the strengths of the study, it has some limitations that need to be acknowledged. First, the current findings are confounded to a cross-sectional design, as it is difficult to establish a temporal relationship between the study variables. Also, the cluster design which we selected the schools by could have contributed to a homogenous sample within each cluster yielding a possible limitation in the sample size and effect size. However, random sampling of schools, classes, and students might have overcome this limitation. Similarly, the schools were selected in only one part of Jordan, and this could have limited the generalizability of the findings to other regions in Jordan. Additionally,

regression analysis of the 7 predictors has shown significant association, where about 27.4% of the variance in reasoning is explained, however other factors, not measured in the current study, might have contributed to the findings. Furthermore, self-reported questionnaires could have yielded subjective data. Therefore, future longitudinal studies using more robust statistical methods and objective biomarkers are needed to confirm these findings.

Recommendations for Future Research

Future national research need to assess the effect of other factors that were not investigated in the current study on reasoning skills such as water and air pollution, the effect of breast feeding, the presence of other medical conditions such as obesity (Barrigas and Fragoso 2012; Kent et al. 2010), the effect of culture and children' bilingualism (Riggs and Young 2016; Gordon 2015), living in safe environment (Danese et al. 2016; Scrimin et al. 2009), parenting style (Sheinkopf et al. 2016; Thompson and Foster 2014; Meindertsma et al. 2014), birth weight (Morgan et al. 2016; Potharst et al. 2013), and the amount of child's physical activity. Knowledge of the correlations of these factors with reasoning skills could provide a baseline for developing and assessing the effectiveness of relevant interventions and rehabilitation programs on Jordanian school children. Such programs could explore the effect of different intervention programs and strategies such as parental involvements in these programs, the effect of breast feeding, physical activity and special diets on reasoning skills, as well as other cognitive abilities (Curi et al. 2016; Belloso-Diaz et al. 2015; Liu et al. 2015; Barkl et al. 2012).

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Compliance with Ethical Standards

Conflict of interest All authors report no conflict of interests.

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