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A comparison of using the DSM-5 and MABC-2 for estimating the developmental coordination disorder prevalence in Korean children

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ABSTRACT

Background: Previous literature has shown inconsistency in the prevalence of developmental coordination disorder (DCD). The Movement Assessment Battery for Children, Second Edition (MABC-2) is often used for DCD prevalence studies, although the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) recommends four criteria.

Aims: The purpose of this study was to compare the prevalence of DCD in Korean children using the DSM-5 and MABC-2.

Methods: A total of 548 Korean elementary school students (mean age: 8.5 years ± 4.5 months) completed this study procedure. All four criteria defined by the DSM-5 were used to classify children with DCD. MABC-2 test scores were used to classify students into four subgroups: high-risk DCD, mild-risk DCD, probable DCD and typical development.

Results: Cohen's kappa revealed that the estimates of DCD prevalence were not significantly different between MABC-2 and DSM-5. When DSM-5 criteria were applied, 60 children out of 548 were classified as probable DCD (10.94%) compared to 70 children with probable DCD (12.77%) when MABC-2 was used.

Conclusions: DCD prevalence based on DSM-5 is not significantly different from MABC-2, though it tends to estimate less than MABC-2. Future studies should consider our findings when selecting an assessment tool.

What this paper adds?

The DSM-5 criteria were applied to investigate the prevalence of DCD for the first time. Results of DCD prevalence from previous studies are mostly based on a single assessment of motor coordination (i.e., MABC-2, Bruininks-Oseretsky Test of Motor Proficiency). However, estimating the prevalence of DCD from a single assessment can be misleading, potentially misidentifying typically developing individuals as having DCD because of their lower performance in one motor assessment, thus overestimating the prevalence. In an effort to minimize this limitation of a single assessment, this study investigated the prevalence of DCD in 548 school-aged

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children in Korea, first using a single assessment, then applying the DSM-5 criteria and compared both results.

1. Introduction

Developmental coordination disorder (DCD) is a neurodevelopmental disorder characterized by an impairment in motor coordination (American Psychiatric Association, 2013). Children with DCD commonly experience a lack of fundamental motor skills, which often limits their ability to perform activities of daily living and participate in physical activities (Faught, Hay, Cairney, & Flouris, 2005; Poulsen, Ziviani, Cuskelly, & Smith, 2007). Diminished physical activity may compromise their cardio-respiratory fitness and thus increase the risk of developing cardiovascular diseases (Hay, Cairney, Faught, & Flouris, 2003; Raynor, 2001; Watkinson et al., 2001). Children with DCD have also shown a decrease in academic performance (Missiuna, Moll, King, King, & Law, 2007; Smyth & Anderson, 2000) along with emotional and behavioral issues (Cantell, Smyth, & Ahonen, 1994; Skinner & Piek, 2001). Furthermore, they may experience negative socialization during the process of play-based activities (Kanioglou, Tsorbatzoudis, & Barkoukis, 2005). These concomitant issues with DCD, which tend to be prolonged throughout adolescence and adulthood if unaddressed, emphasize the importance of an early diagnosis and intervention (Fitzpatrick & Watkinson, 2003; Geuze & Börger, 1993).

Previous literature have reported a wide range of probable DCD prevalence that varies from 4 to 32.8% among school-aged children around the world (Amador-Ruiz et al., 2018; De Milander, Coetzee, & Venter, 2016; Delgado-Lobete, Santos-del-Riego, Pértega-Díaz, & Montes-Montes, 2019; Lingam, Hunt, Golding, Jongmans, & Emond, 2009; Tseng, Fu, Wilson, & Hu, 2010; Valentini, Clark, & Whitall, 2015; Wright & Sugden, 1996). The wide variance of DCD prevalence appears to be associated with differences in methods, such as cut-off percentiles, assessment tools, and samples (Valentini et al., 2015). Cultural backgrounds also cannot be ignored when studying the prevalence of DCD (Tsiotra et al., 2006). Estimates have reported a wide range of prevalence among different countries. For instance, high-risk DCD was observed in 1.4% of children in Singapore (Wright & Sugden, 1996), 1.8% of children in England (Lingam et al., 2009), 3% of children in Columbia (Pineda, Lopera, Palacio, Ramirez, & Henao, 2003), 3.5% of children in Taiwan (Tseng et al., 2010), 6% of children in South Africa (De Milander et al., 2016), 7.3% of children in Sweden (Gillberg, Carlström, Rasmussen, & Waldenström, 1983), 8% of children in Canada (Tsiotra et al., 2006), 9.9% of children in Spain (Amador-Ruiz et al., 2018), 17.8% of children in Brazil (Valentini et al., 2015), and 19% of children in Greece (Tsiotra et al., 2006). Also probable DCD was found in 4% of children in Singapore (Wright & Sugden, 1996), 4.9% of children in England (Lingam et al., 2009), 12% of children in South Africa (De Milander et al., 2016), 12.2% of children in Spain (Delgado-Lobete et al., 2019), 17.9% of children in Taiwan (Tseng et al., 2010), and 32.8% of children in Brazil (Valentini et al., 2015).

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), which contains four different criteria for DCD diagnosis, is recommended for health care professionals and researchers (American Psychiatric Association, 2013). Based on the DSM-IV, Lingam et al. (2009) reported 1.7% of children (mean age: 7.5 years ± 2.9 months) with a high-risk DCD in England. Most DCD prevalence studies, however, have not rigorously applied all four criteria of the DSM to their screening procedure (Amador-Ruiz et al., 2018; Kokstejn, Psotta, & Musalek, 2015; Tsiotra et al., 2006; Valentini et al., 2015). When examined by the Movement Assessment Battery for Children-2 (MABC-2: Henderson, Sugden, & Barnett, 2007) alone, the high-risk DCD prevalence ranged from 9.9% to 17.8% in 4–6 years (Amador-Ruiz et al., 2018; Valentini et al., 2015). Depending on which motor assessment tools were used, the prevalence of high-risk DCD varied from 1.4% (Kokstejn et al., 2015) to 19% (Tsiotra et al., 2006) in school-aged children (mean age: 11.3 years).

Studies based on a single motor assessment tool appear to overestimate the prevalence of DCD compared to those based on multi-criteria DSM factors (Amador-Ruiz et al., 2018; Lingam et al., 2009; Valentini et al., 2015). Such an overestimated DCD prevalence may only reflect the number of children who performed poorly in standardized motor assessment tools rather than the actual number of children who experience difficulties in daily living and have limited ability to participate in physical activity. Therefore, the purpose of this study was to compare the use of the DSM-5 and MABC-2 for estimating the prevalence of DCD in Korean children. In addition, the present study compared the DCD prevalence in Korean children to that of other countries. It was hypothesized that the use of MABC-2 would overestimate DCD prevalence in Korean children compared to using the DSM-5 criteria. We also hypothesized that the prevalence of DCD in Korean children would be similar to that in other countries.

2. Methods

2.1. Participants

Ten elementary schools from the city of Incheon, a metropolitan urban setting, were randomly selected and invited to participate in this study. A total of six schools' administrators agreed to participate in this project. A total of 568 elementary students (age range of 8–9 years, 283 boys, 285 girls) were initially recruited and screened for this study. Exclusion criteria were: (1) medical conditions or neurological disabilities beside DCD attributing to motor skill deficits (2) long-term absences from school, (3) no submission of the Developmental Coordination Disorder Questionnaire 2007 (Wilson, Kaplan, Crawford, & Roberts, 2007) by the child' parents, or (4) unreliable results from the questionnaire (i.e., using the same number to respond to all answers). A total of 548 (mean age: 8.5 years ± 4.5 months; 271 boys, 277 girls) children were assessed using the DSM-5 criteria, and the data was used for this study. This study protocol was approved by a university's Institutional Review Board (IRB No. 1603/001-028) and an informed consent for participation was obtained from all children, parents, and relevant school officials. There was no conflict of interest in this investigation.

2.2. Procedures and instruments

2.2.1. DSM-5 and MABC-2

We used all four criteria defined by the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). These are criterion A (motor coordination skills deficit), criterion B (activities of daily living & school performance), criterion C (onset of symptoms), and criterion D (medical condition). We systematically followed four steps described below in order to minimize potential errors when using the DSM-5: In step 1, as for criterion A, we checked if the total score of the MABC-2 (Henderson et al., 2007) was below the 15th percentile; step 2, as for criterion B, we checked if a total score of Developmental Coordination Disorder Questionnaire 2007 (DCDQ'07) was below 55 (Wilson et al., 2007) and if both grades of academic performance and physical education adherence were not above average (grade A); step 3, as for criterion C, we checked student's age on the school record; step 4, as for criterion D, we checked student's health record to see if there was any medical conditions or neurological disabilities.

In addition, MABC-2 test scores were used to classify students into four subgroups: high-risk DCD ($\leq$ 5th percentile), mild-risk DCD (6th–15th percentile), probable DCD ($\leq$15th percentile), and typical development (TD; > 15th percentile).

2.2.1.1. Motor coordination skills assessed via MABC-2. The Movement Assessment Battery for Children, Second Edition (MABC-2) was used for this study (Henderson et al., 2007). This battery includes three categories of motor tasks: manual dexterity, aiming and catching, and balance. Trained evaluators visited each school and assessed the motor coordination skills of participants in school gymnasiums following the guidelines in the MABC-2 manual. Each evaluation was conducted as a one-on-one interaction with each student and took approximately 30–40 minutes to complete.

The raw score of MABC-2 was normalized based on age and converted into a percentile based on the MABC-2 manual. Two cut-off values were applied to define the level of motor coordination difficulties, as stated in previous studies (Amador-Ruiz et al., 2018; Kokstejn et al., 2015; Tsiotra et al., 2006; Valentini et al., 2015). A total score below 56 (the 5th percentile or less) on MABC-2 was classified as severe motor coordination difficulties, whereas a total score below 67 (the 15th percentile or less) was classified as indicating a risk of motor coordination difficulties for DCD (Geuze, Jongmans, Schoemaker, & Smits-Engelsman, 2001). Based on the MABC-2 score, participants were classified into four subgroups: high-risk DCD ($\leq$ 5th percentile), mild-risk DCD (6 – 15th percentile), probable DCD ($\leq$ 15th percentile), and typical development (TD; > 15th percentile).

2.2.1.2. Parental perspective on children's developmental coordination in activities of daily living. The Developmental Coordination Questionnaire 2007 (DCDQ-07) is a tool for parents to evaluate their children's degree of coordination in activities of daily living (ADL). The questionnaire contains 15 items in three subcategories: control during movement, fine motor/handwriting, and general coordination. The DCDQ-07 has shown a high intra- and inter-reliability score in children aged 5–15 years (Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000). The validated Korean version of the DCDQ-07, the DCDQ-K-07 (Lee, Choi, Kim, & Lee, 2016) was adopted for this study and mailed to parents/guardians. They were asked to rate the daily motor coordination ability of their children on a 5-point Likert scale (1 = "not at all like my child"; 5 = "extremely like my child"). The primary investigator collected completed surveys via mail. Each item was scored from 1 to 5 points, with a total score ranging from 15 to 75, which was used to determine DCD. Students who scored below 55 were classified as experiencing probable DCD.

2.2.1.3. School performance assessed via school report and teacher interview. School performance was assessed based on objective academic evaluation and teacher interviews regarding each participant's academic performance and physical education adherence. Each participant's teacher evaluated that student's school performance following the grading criteria of A (above average), B (average), and C (below average). If a student earned a grade of A in both academic performance and physical education adherence, he or she was not considered for DCD classification.

2.2.1.4. Onset of symptoms via the school record. The primary researcher confirmed that the age of each participant was between 5 and 12 using school records (Smits-Engelsman, Schoemaker, Delabastita, Hoskens, & Geuze, 2015). All students recruited in this investigation were in the age range of 8–9.

2.2.1.5. Medical conditions via the school health record. According to the DSM-5 criterion, the primary investigator examined the school health record and then excluded students with medical conditions other than DCD attributing to motor skill deficits, such as severe intellectual disability, cerebral palsy, or muscular dystrophy.

2.3. Statistical analysis

All means and standard deviations were analyzed using SPSS version 21.0 (SPSS Inc., Chicago, IL). Chi-square tests were conducted for comparing prevalence rates such as high-risk DCD, mild-risk DCD, and TD. Cohen's kappa coefficient test was conducted to compare DCD prevalence between MABC-2 and DSM-5. An independent *t*-test and one-way analysis of variance (One-way ANOVA) were used to determine between-gender and between-group differences in the MABC-2, respectively. A Scheffe test was conducted as a post-hoc test. The level of significance was set at $p \leq .05$ for all statistical analyses.

Table 1
DCD Prevalence based on the MABC-2 and DSM-5.

	MABC-2			DSM-5		
	Probable DCD		TD	Probable DCD		TD
	High-risk DCD	Mild-risk DCD		High-risk DCD	Mild-risk DCD	
Boys	5 (0.91%)	39 (7.11%)	227 (41.42%)	4 (0.73%)	33 (6.02%)	234 (42.70%)
Girls	3 (0.55%)	23 (4.20%)	251 (45.81%)	2 (0.36%)	21 (3.83%)	254 (46.35%)
Total	8 (1.46%)	62 (11.31%)	478 (87.23%)	6 (1.09%)	54 (9.85%)	488 (89.05%)

Note. DCD, developmental coordination disorder; TD, Typical development, MABC-2, Movement Assessment Battery for Children, second edition; DSM-5, Diagnostic and Statistical Manual of mental disorder fifth edition.

3. Results

A total of 568 children were evaluated for motor coordination skills; five failed to complete the MABC-2. For DCDQ-K-07, 552 questionnaires (98%) were returned with responses; however, teacher interviews could not be completed for two of the participants with completed questionnaires due to long-term absences, and two participants were classified as having intellectual disabilities for whom teachers could not provide letter grades for school performance. Thus, data from 548 students were included in our analysis.

3.1. Prevalence of DCD based on the MABC-2

Out of 548 participants (mean age: 8.5 years ± 4.5 months) who completed the MABC-2, 70 children (12.77%; 44 boys, 26 girls) had probable DCD, scoring below the 15th percentile; eight children (1.46%; 5 boys, 3 girls) were identified as high-risk DCD, scoring below the 5th percentile, and 62 children (11.31%, 39 boys, 23 girls) as mild-risk DCD, scoring the 6–15th percentiles (Table 1). DCD was more common in boys than girls (1.70:1) in those with probable DCD, similar to the high-risk DCD group (1.67:1). However, the gender differences did not show statistical significance based on Chi-square tests ($p = 0.056$). Children with probable DCD did not show any gender differences in either the total scores or the components scores of MABC-2(Table 2).

3.2. Prevalence of DCD based on the DSM-5

When DSM-5 criteria were applied, 60 children out of 548 (10.94%; 37 boys, 23 girls) were classified as probable DCD as compared to 70 children with probable DCD when MABC-2 was used. However, Cohen's kappa coefficient analysis revealed the difference in the estimated rate of prevalence was not statistically significant between MABC-2 and DSM-5 (kappa value = .885, $p \leq .05$). Among 60 children with probable DCD, 1.09% showed high-risk DCD (6 children; 4 boys, 2 girls) and 9.85% mild-risk DCD (54 children; 33 boys, 21 girls) (Table 1).

Use of the DSM-5 criteria showed a trend of 1.83% lower prevalence of probable DCD than MABC-2. Chi-square tests revealed no significant gender differences in the prevalence of probable DCD, high-risk DCD, and mild-risk DCD. However, it was noted that the prevalence of probable DCD was 1.61 times higher in boys than girls.

A total score of the MABC-2 was divided into three components: manual dexterity, aiming and catching, and balance. Children with high-risk DCD showed significantly lower total scores on MABC-2 than those with mild-risk DCD and TD (Table 3). Post-hoc comparisons revealed significantly lower scores in all three components in children with DCD (both high- and mild- risk DCD) as compared to TD. Significant differences between high- and mild-risk DCD were found only for scores on the manual dexterity and balance components.

Table 2
Gender Differences in Standards Score in Component of the MABC-2 in Children with Probable DCD ($\leq 15^{th}$ %).

	Boys (n = 44)	Girls (n = 26)	*p*-value
Manual dexterity	6.8 ± 1.7	6.6 ± 1.5	.803
Aiming and catching	5.5 ± 2.2	4.6 ± 1.4	.120
Balance	8.5 ± 1.7	9.1 ± 1.2	.288
Total MABC-2	6.3 ± 1.2	6.3 ± 0.9	.920

Note. DCD, developmental coordination disorder; MABC-2, Movement Assessment Battery for Children, second edition; Tested by independent *t*-test.

Table 3
The MABC-2 Subcomponents Score in Children with DCD identified as DCD according to DSM-5.

	Probable DCD (n = 60)		TD (n = 488)
	High-risk DCD: MABC-2 score $\leq 5^{th}$ % (n = 6)	Mild-risk DCD: MABC-2 score 6–15^{th} % (n = 54)	TD: MABC-2 score $> 15^{th}$ % (n = 488)
Manual dexterity	16.05 ± 2.55	21.88 ± 3.75[a]	31.14 ± 5.92[b,c]
Aiming and catching	10.28 ± 1.01	11.45 ± 2.38	18.19 ± 3.92[b,c]
Balance	23.01 ± 3.98	27.99 ± 3.48[a]	31.77 ± 3.48[b,c]
Total MABC-2	49.34 ± 1.85	61.32 ± 3.31[a]	81.10 ± 5.68[b,c]

Note. DCD, developmental coordination disorder; MABC-2, Movement Assessment Battery for Children, second edition; Tested by one-way analysis of variance with post-hoc (Scheffe's), $p < .05$, a: high-risk DCD vs. mild-risk DCD, b: high-risk DCD vs. TD, c: mild risk DCD vs. TD.

4. Discussion

4.1. DCD prevalence comparison between the MABC-2 and DSM-5

This investigation was the first study to compare the prevalence of DCD in children using the DSM-5 and MABC-2. Our findings revealed that the estimates of DCD prevalence were not significantly different between MABC-2 and DSM-5. Although not significant, a trend was noted that an estimate of DCD prevalence could be lower when using DSM-5 as compared to MABC-2. The American Psychiatric Association (2013) reported that the estimated DCD prevalence was 5–6% in school-aged children, while previous literature has revealed a wider range from 1.4% (Kokstejn et al., 2015; Lingam et al., 2009) to 19% (Tsiotra et al., 2006; Valentini et al., 2015).

This discrepancy may be associated with inconsistent methods used in previous studies. Previous studies that reported higher DCD prevalence (9.9–19%) (Amador-Ruiz et al., 2018; Tsiotra et al., 2006; Valentini et al., 2015), utilized a single assessment tool to only assess the motor coordination component (i.e. MABC-2 or the Bruininks-Oseretsky Test of Motor Proficiency) or a questionnaire-based assessment only (i.e. DCDQ-07 or Checklist MABC-2), instead of using a comprehensive assessment. Our findings also showed a consistent trend in which the use of MABC-2 elicited higher estimates of DCD prevalence than DSM-5 criteria among school-aged children.

4.2. Prevalence of DCD among Korean children

Our results showed that the prevalence of high-risk DCD was 1.09% in Korean children aged 8–9 years based on results from the DSM-5. This prevalence of high-risk DCD in Korean children is in a similar range to previous studies: 1.8% in English children (Lingam et al., 2009) and 1.4% in Czech Republic children (Kokstejn et al., 2015). On the other hand, the prevalence of mild-risk DCD in Korean children (9.85%) demonstrated a similar estimate to that of Greek children (10.8%) (Kourtessis et al., 2008) and Spanish children (9.9%) (Amador-Ruiz et al., 2018). However, this differed compared to estimates from English children (13.7%) (Schoemaker, Lingam, Jongmans, van Heuvelen, & Emond, 2013) and Czech Republic children (5.1%) (Kokstejn et al., 2015). It is interesting to note that the estimates of high-risk DCD prevalence were similar, whereas mild-risk DCD prevalence was estimated quite differently from each other.

The differences in DCD prevalence between Korean children and those from other countries appear to be associated with multiple factors. It is possible that DCD prevalence can be different from country to country due to geographical and cultural differences. Some DCD prevalence studies are based on countries which may have a mostly rural environment where physical activity is easily accessible and often integrated into children's daily activities. For instance, mild-DCD prevalence in Korean children (9.85%) was higher than that from Czech Republic study (5.1%). Our sampling of Korean children was based on elementary school students from Incheon city, a metropolitan urban setting. Those geographical and cultural differences might contribute to inconsistent estimates of DCD prevalence from different countries. In addition, estimates of DCD prevalence can be affected by ages of sampling. A trend of higher DCD prevalence has been reported as the age of children increased from 6 to 7 years old (4.9%) to 8–9 years old (11.7%) (Delgado-Lobete et al., 2019). Our estimated of mild-risk DCD prevalence was based on Korean children aged 8–9 years, consistent with the age range from the Spanish study (Delgado-Lobete et al., 2019). However, it is higher than the mild-risk DCD prevalence of 6% from South African, which was measured among 5-8-year-old children (De Milander et al., 2016).

Our results did not show a significant gender difference in DCD prevalence. It is notable that some previous research has reported a higher prevalence in boys than girls (Hua et al., 2014; Tseng et al., 2010; Zwicker, Missiuna, Harris, & Boyd, 2012), while other studies, like ours, have documented no significant gender difference (Amador-Ruiz et al., 2018; De Milander et al., 2016; Kokstejn et al., 2015). It is interesting to note that when observed, it appears the gender difference in DCD prevalence can be contingent upon children's age (Delgado-Lobete et al., 2019). Delgado-Lobete and colleagues (2019) reported that no gender difference in DCD prevalence was found among children 8–9 years old, whereas significant differences were revealed in other age groups. Our results from Korean children 8–9 years old were in agreement with their findings.

Further analysis of MABC-2 subcomponents revealed that both children with high- and mild-risk DCD scored significantly lower in

all three categories. Children with high-risk DCD showed greater motor deficits in the manual dexterity and balance as compared to those with mild-risk DCD. However, both children with high- and mild-risk DCD seemed to struggle similarly with the aiming and catching subcomponent. In addition, subcomponent scores from children with probable DCD based on MABC-2 were compared to those based on DSM-5 and this comparison did not reveal any significant differences, as well as a notable trend. In regard to gender differences in performing subcomponents, both boys and girls showed a similar trend scoring lowest on aiming and catching and highest on balance skills. It was also observed that girls tended to score higher on balance than boys, whereas boys scored higher on aiming and catching. This trend is consistent with findings in previous studies (Giagazoglou et al., 2011; Kokstejn et al., 2015; Smits-Engelsman, Henderson, & Michels, 1998). It may be associated with gender difference in physical activity preferences, and play duration and frequency (Giagazoglou et al., 2011; Hardy, Reinten-Reynolds, Espinel, Zask, & Okely, 2012).

4.3. Limitations

We acknowledge that there are limitations in this study. The present study recruited children from six public schools in Incheon city, a metropolitan urban setting; therefore, inferences to all Korean children should be made cautiously. We listed medical condition beside DCD attributing to motor skill deficits among the exclusion criteria. No children with developmental disabilities, such as autism spectrum disorder or cerebral palsy, were excluded in our study. However, we had to exclude two children with intellectual disabilities for whom teachers could not provide letter grades indicating school performance. Future DCD prevalence studies should make a careful consideration in this regard as the DSM-5 contemplates that DCD can co-occur with other medical conditions.

We also evaluated school performance based on school records and teacher interview, for which the questions were not validated. Thus, there is a possibility of potential error or bias in the interview process. Lastly, the performance of ADL was assessed using a Korean version of the DCDQ. Although the content validity and reliability were previously established, the use of the same-cut off score as in the original DCDQ was not validated.

5. Conclusion

Our study compared the use of the DSM-5 and MABC-2 for estimating the prevalence of DCD in Korean children. In addition, we compared the DCD prevalence in Korean children to those of other countries. Our findings demonstrate that the estimates of DCD prevalence is not significantly different between MABC-2 and DSM-5. However, our results suggest a trend that an estimate of DCD prevalence tends to be lower when using DSM-5 compared to MABC-2. Our results also illustrate that the prevalence of high-risk DCD in Korean children appears similar to that of other countries, but that of mild-risk DCD can be different. Future investigation of DCD prevalence should consider these findings when selecting an assessment tool and take into account cultural, geographical and age factors.

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