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Exploring the Predictive Relationship between Creative Self-Efficacy and Spatial Visualization Ability in Gifted Students

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Abstract

This research investigated the predictive relationship between Creative self-efficacy and Spatial visualization ability among gifted high school students in Saudi Arabia, in light of the knowledge transformation required to achieve the Kingdom's Vision 2030. The study utilized Bandura's social-cognitive theory framework to address a notable gap in Arabic literature regarding the interplay between cognitive experience and affective belief. The study used a descriptive correlational approach, applying the Revised PSVT:R and the Creative Self-Efficacy Scale to a sample of gifted high school students. The descriptive results showed that the sample had very high levels of both creative self-efficacy and spatial visualization ability, confirming the superior affective and cognitive characteristics of this group. The results of the correlation analysis showed a positive and statistically significant correlation between creative self-efficacy and spatial visualization ability. ($r = 0.48$, $p < 0.001$). More importantly, linear regression analysis revealed that spatial visualization ability statistically significantly predicts creative self-efficacy ($B = 0.49$, $p < 0.001$), with spatial visualization explaining approximately 23% of the variance in creative self-efficacy among gifted students. The study concludes that cognitive superiority in spatial ability acts as a cognitive lever that enhances students' affective confidence in their ability to innovate, supporting the hypothesis of reciprocal interaction between creative self-efficacy and spatial visualization ability. The study recommends the integration of intensive and systematic spatial visualization training programs into gifted education curricula, not only to improve technical skills, but also to enhance their creative self-efficacy and support the development of creative human capital to achieve national development goals.

Keywords: *Spatial visualization ability, creative self-efficacy, gifted individuals, prediction, Pandora theory.*

Introduction

The modern world is going through a deep knowledge and economic shift driven by the science and tech revolution. Modern economies are no longer measured by their natural resources, but by their ability to invest in human capital that can think creatively and solve complex problems (Muzam, 2023).. In light of this transformation, the development of scientific and engineering talent has become a fundamental pillar of sustainable development, as the challenges of the 21st century require a generation of innovators capable of combining logical analysis with visual perception and creative imagination (Council et al., 2012). Gifted students are a valuable national asset, as their cognitive and emotional abilities enable them to move from absorbing knowledge to generating and applying it in innovative solutions(Tatarinceva et al., 2018). In his (Wisdom, Intelligence, Creativity, Synthesized), WICS model, Sternberg et al. (2005) argues that true talent arises from the interaction between intellectual ability, commitment to achievement, and creativity. Therefore, understanding the cognitive and affective factors that support this interaction is essential for developing gifted education programs that are the driving force behind modern development, (Papadopoulos, 2020).

Spatial visualization ability SVA is one of the most important cognitive abilities associated with superior performance in science and engineering (Tiwari et al., 2024). It is defined as an individual's

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ability to mentally imagine and manipulate shapes in three-dimensional space and understand the spatial relationships between them (Nagy-Kondor, 2016; Shongwe & Technology, 2022). Carroll (1993) argues that spatial ability is not a single dimension, but rather encompasses distinct components such as spatial visualization, spatial orientation, and understanding spatial relationships. Several studies have confirmed that SVA is a strong predictor of success in scientific disciplines (Nolte et al., 2024; Sein et al., 1993; Titus & Horsman, 2009), sometimes surpassing verbal or numerical abilities (Uttal et al., 2013). A long-term study by Wai et al. (2009) showed that spatial perception has greater predictive validity for scientific and engineering achievement than intelligence tests and academic achievement. Wai et al. (2009) warned that neglecting to develop these abilities means a loss of national intellectual capital, especially since most gifted individuals belong to the visual-spatial learner category (Silverman, 2002). Recent studies (Alqahtani et al., 2017; Miller et al., 2013; Sorby, 1999) have also shown that regular training in spatial visualization skills improves performance in technical drawing and 3D design and fosters design creativity.

However, cognitive abilities alone are not sufficient for creative achievement without an emotional stimulus to support and guide them. This is where the concept of self-efficacy, as proposed by Bandura (1985); (Bandura, 1997) in his social cognitive theory, comes into play. Self-efficacy is defined as an individual's belief in their ability to organize and execute the actions required to achieve specific outcomes. Self-efficacy arises from four main sources: achievement experiences, learning by modeling, social persuasion, and affective states (Hammad et al., 2020; Ramachandran, 2012). From this framework emerged the concept of Creative Self-Efficacy (CSE), defined by Tierney and Farmer (2002) as an individual's belief in their ability to produce new and valuable ideas. CSE represents the affective-cognitive dimension that drives creativity by enhancing motivation, perseverance, and mental flexibility (Zandi et al., 2022). Vieira et al. (2025) emphasized that CSE has become a central educational component in science, and Technology education, as it promotes confidence in the learner's ability to innovate new solutions. Karwowski et al. (2019) also showed that measuring CSE is more accurate than general self-efficacy in explaining creative behavior because it focuses on a specific set of affective beliefs related to creativity.

Social-cognitive theory suggests that there is a reciprocal interactive relationship between SVA and CSE; SVA is a cognitive source for the formation of CSE through achievement experience that generates a sense of competence and confidence (Hammad & Awed, 2023; Safadel et al., 2023). When gifted students succeed in performing complex visual-spatial tasks, they develop a belief in their ability to be creative in this area, which raises their CSE. Betts et al. (2023) showed that virtual reality training in SVA skills leads to a significant improvement in spatial self-efficacy, while Höffler (2010) explained that spatial visualization reduces the cognitive load in scientific learning, freeing up more resources for innovation. In contrast, CSE acts as a motivating and mediating factor: the more confident a student is in their creative ability, the more they engage in tasks that require SVA, exert greater effort, and tolerate failure (Cheng et al., 2024). Redifer et al. (2021) also showed that self-efficacy mediates the relationship between visuospatial performance and design innovation, confirming the hypothesis of a reciprocal relationship between SVA and CSE as formulated by Fü rst et al. (2016). In the national context, investing in talented individuals is a central part of achieving the Kingdom's Vision 2030, which seeks to build a knowledge-based economy based on innovation (Khan, 2016). Mega national projects such as Neom, The Line, and The Red Sea require a generation of engineers and innovators capable of thinking in three dimensions and transforming complex visions into realistic, innovative designs. The Gifted Foundation plays a leading role in discovering and nurturing this group. Hence, studying the relationship between SVA and CSE among gifted Saudi students has both theoretical and practical significance, as its findings can contribute to the development of educational programs that integrate spatial visualization training with the promotion of creative confidence through tools such as virtual reality, digital modeling, and project-based learning. Preliminary Arab studies (Al-Zghoul & Al-Dababi, 2014) have shown that there is a positive relationship between spatial ability and creative thinking, confirming the need to expand this research in Saudi gifted environments.

Despite the global research momentum surrounding SVA and CSE separately, studies addressing the interrelationship between the two in the context of gifted students remain scarce, especially in Arab contexts. Most previous studies have focused on general university samples or artistic creativity, ignoring the cognitive and emotional specificity of gifted individuals. Arab and Saudi research rarely employs Bandura's framework to explain how spatial experience translates into affective confidence that leads to creative behavior. Therefore, there is a need for quantitative studies that explain the extent to which SVA contributes to the development of CSE among gifted Saudi students in science and engineering, and how this relationship can be used to design more effective educational programs.

Based on the above, this research aims to analyze the predictive relationship between spatial visualization ability and creative self-efficacy among gifted students in science and engineering tracks in Saudi Arabia. Its importance stems from two aspects: theoretically, it is one of the first Arab studies to use Bandura's theory to explain the interaction between cognitive experience SVA and affective belief CSE, enriching the scientific literature with a new affective mediation model; Practically, it provides a framework that talent programs and educational institutions can use to develop educational interventions based on the integration of cognitive and affective training, thereby supporting the building of creative capital to achieve the goals of Vision 2030. Therefore, the questions of the current study can be defined as follows: 1. What is the level of spatial visualization ability and creative self-efficacy among gifted students in science and engineering? 2. Is there a statistically significant relationship between spatial visualization ability and creative self-efficacy? 3. To what extent can creative self-efficacy be predicted by spatial visualization ability in this group of gifted students?

Methodology

Research Design

This study adopted a descriptive correlational approach, which is most appropriate for achieving the research objectives. This approach aims to describe the level of the variables under study (SVA and CSE), explore the nature and direction of the correlation between them, and examine the possibility of predicting one variable based on the other. This approach was chosen because it allows phenomena to be studied as they occur in natural reality without experimental intervention, providing an accurate description of the cognitive and affective characteristics of gifted student samples.

Participants

The study population consisted of all gifted male and female students enrolled in secondary school talent development programs in science and engineering tracks in secondary schools in the southern region (Abha, Najran, and Jazan). The study sample was selected using stratified random sampling to ensure adequate representation of gender in the study environment, as gender is believed to be a factor that may affect spatial ability. The basic study sample consisted of 264 students (127 males, 135 females) (M = 17.2 years; SD = 1.02 years). This sample was selected from gifted students who were officially identified and classified as gifted based on screening measures approved by the authority supervising gifted programs in the educational district. We determined the sample size using G*Power version 3.1.9.7 for all statistical tests, applying a significance level of $\alpha = 0.05$ and a power of 85%. The recommended sample size for one-way analysis of variance was 180, and this requirement was met in the basic sample.

Measures

The Revised Purdue Spatial Visualization Test: Visualization of Rotations - Revised PSVT:R

The Revised Purdue Spatial Visualization Test (Yoon, 2011): Visualization of Rotations is a revised version of the original PSVT:R (Guay, 1976). This test aims to identify individuals' ability to mentally rotate three-dimensional shapes and is suitable for individuals aged 13 years and older. The measure consists of 30 items of increasing difficulty and has a time limit of 20 minutes. The measure includes a scale of angles and number of axes of rotation. The assessment is based simply on the number of items answered correctly. Content validity was verified by a group of academic arbitrators. The internal consistency coefficient (Cronbach's alpha) (α) on the current study sample was 0.85, confirming a very high level of internal consistency for the scale.

Creative Self-Efficacy Scale

The Creative Self-Efficacy Scale (Karwowski et al., 2018) (Karwowski, 2012, 2014; Karwowski et al., 2018) aims to assess the extent to which students believe in their ability to generate new, appropriate, and effective ideas in the context of problem solving. The scale consists of six items, which are answered using a five-point Likert scale, with a possible total score ranging from 6 to 30. The content validity was verified by a group of academic referees. The internal consistency coefficient (Cronbach's alpha) (α) on the current study sample was 0.88, confirming a very high level of internal consistency for the scale.

Procedures

Before conducting the study, ethical approval was obtained from the Deanship of Scientific Research at Najran University in Saudi Arabia. Informed consent was also obtained by obtaining written consent from students and their parents to participate in the study, emphasizing the voluntary nature of participation, data confidentiality, and the right to withdraw.

To achieve the study objectives, two reliable standardized tools were used, both of which underwent a process of normalization and adaptation to the Saudi environment. All measurements in this study were conducted in Arabic. To ensure that the Arabic translation had the same meaning as the original questionnaire, language experts translated the psychometric instruments listed below from English into Arabic and then back into English. The English department at the Researchers First Foundation first translated the English version into Arabic. Then another professor, whose native language is Arabic and who specializes in English, translated the Arabic version back into English. After that, three specialists in Arabic, psychology, and English evaluated the Arabic and English translations.

The study tools were applied collectively in a standardized classroom environment by the students' teachers, who were trained on how to administer the test, its instructions, and its purpose. The spatial perception test was administered first to avoid any bias that might result from the creative self-efficacy scale responses. The Revised PSVT:R test took 20 minutes to complete, while the creative self-efficacy scale took about 5 minutes. All tools were completed under the supervision of the collaborating teachers.

Data Analysis

The Statistical Package for the Social Sciences (SPSS-22) was used to analyze the data. To achieve the study objectives and answer the study questions, descriptive statistics were applied to answer the first question, using arithmetic means (M), standard deviations (SD), and frequencies to provide a quantitative description of the level of the variables. Pearson's correlation coefficient was also used (to answer the second question) to calculate the strength and direction of the correlation between students' scores on the spatial perception test and their scores on the creative self-efficacy scale. Finally, simple linear regression was analyzed (to answer the third question) by determining the predictability of creative self-efficacy (dependent variable) through spatial visualization ability (independent variable). The necessary statistical assumptions (linearity, normal distribution, independence of residuals) were examined before performing the analysis.

Results

Descriptive Statistics and Performance Level

To answer the first question of the study, which states: What is the level of spatial visualization ability and creative self-efficacy among gifted students? Table 1 shows the means and standard deviations of the study variables.

Table 1. Descriptive Statistics for Study Variables (N=246)

Variable	Min	Max	M	SD	Max Possible Score	Performance
SVA	14	30	24.52	2.91	30	High
CSE	18	30	25.16	2.23	30	High

The results in Table 1 indicate that gifted students performed significantly higher in both spatial visualization ability and creative self-efficacy. The mean score on the SVA test (M = 24.55) was well above the midpoint of the test (15), indicating high mental rotation ability. Similarly, the mean scores on the CSE test (M = 25.20) were high, reflecting strong confidence in their creative abilities.

Correlation between SVA and CSE

To answer the second question, we studied the correlation between SVA and CSE. Pearson's correlation coefficient was analyzed for the moment, as shown in Table 2.

Table 2. Correlation Matrix Between SVA and CSE

Relationship	*r*	p-value
SVA and CSE	0.42	<0.001

The results in Table 2 indicate a statistically significant positive correlation between SVA and CSE (*r* = 0.48, $p < 0.001$). This result indicates a moderate relationship, whereby students with high spatial visualization skills tend to feel that they are highly capable of generating creative and innovative ideas.

Predictive SVA and CSE

To answer the final question of the study, which refers to attempting to determine the extent to which SVA predicts CSE, a simple linear regression analysis was performed, with CSE as the dependent variable and SVA as the predictor variable. This is shown in Table 3.

Table 3. Simple Linear Regression Analysis Predicting CSE from SVA

Dependent Variable	Predictor	Unstandardized Coefficient (B)	Standardized Coefficient (β)	t	R^2	p-value
CSE	SVA	0.37	0.48	09.03	0.230	<0.001

Table 3 indicates that the regression model is statistically significant ($F(1, 262) = 81.90$, $p < 0.001$). Also, the results in Table 3 indicate that SVA emerged as a statistically significant positive predictor (*B* = 0.49, $p < 0.001$).

The R2 value of 0.230 indicates that 23% of the variance in creative self-efficacy can be explained by students' spatial visualization ability. These results confirm that spatial cognitive skills play an important role in enhancing the creative self-confidence of gifted students.

Discussion

This discussion aims to interpret the results obtained in the current study among the sample of gifted students by linking them to theoretical and conceptual frameworks and comparing them with the results obtained from previous research in the field of giftedness and cognitive-affective abilities. First, the descriptive results Table 1 confirmed that the sample of gifted high school students had very high levels of both spatial visualization ability *M* = 24.55 and creative self-efficacy *M* = 25.20. This increase was expected and confirms the intrinsic cognitive and affective characteristics of the sample selected to participate in gifted programs. This high level is closely consistent with the theoretical basis that classifies spatial ability as one of the strongest cognitive indicators of giftedness, where research consistently indicates that students enrolled in gifted programs outperform their peers in general education on measures of spatial perception, particularly on complex mental rotation tasks measured by the Revised PSVT:R (Uttal et al., 2013; Wai et al., 2009). This finding can be interpreted from two main perspectives. The first is a selective and normative interpretation based on the fact that gifted identification programs in Saudi Arabia do indeed select individuals who possess the superior nonverbal cognitive abilities necessary for success in engineering and science. This is consistent with Wai et al. (2009) warnings that spatial ability is a critical differentiator that determines future career paths in technical fields. It is worth noting that high performance on a timed test such as the SVA reflects not only cognitive ability, but also processing speed and visual coding efficiency. The second explanation is training and developmental, where the increase also indicates that the advanced educational environments provided by gifted programs have enhanced this ability through continuous training in three-dimensional problem solving and engineering design, as confirmed by Sorby (2009), who demonstrated that this ability is developable and improvable and not entirely innate. This conclusion is supported by the findings of Höffler (2010), which confirmed a significant improvement in spatial abilities after structured educational interventions. In parallel with this, the high average scores of students on the creative self-efficacy scale are also a result that is fundamentally consistent with the affective frameworks of talent, as confirmed by multiple studies, such as that by (Al-Dhaimat et al., 2020; Al-Zoubi, 2014) in the Arab context have confirmed that the level of creative self-efficacy is very high among gifted and high-achieving students, adding evidence that gifted individuals not only possess mental abilities but also have the affective driver necessary to translate these abilities into actual performance. This increase can be explained from the perspective of Bandura's theory (Bandura, 1997), where accumulated experiences of achievement in solving difficult problems and winning competitions are a key source of enhancing self-efficacy in their ability to deal with more complex creative tasks (Hammad & Shalhoub, 2024; Karwowski et al., 2018). This is also consistent with Renzulli's Three-Ring Conception of Talent (Renzulli, 1988), which considers creativity to be an essential component, and is also consistent with Gagne's model (2003), which emphasizes the role of internal motivators as a decisive factor in transforming latent talent into visible and productive achievements, meaning that the current sample has the psychological and cognitive readiness for innovation.

Second, the results of the study Table 2 showed a positive and statistically significant correlation between spatial visualization ability and creative self-efficacy $r = 0.48$, $p < 0.001$. This relatively moderate and strong correlation is a qualitative addition to the existing literature by identifying the relationship between two specific components spatial visualization and creative self-efficacy in a specialized sample gifted individuals. This relationship is explained by cognitive-affective interaction in the creative process: high spatial visualization ability is an enabling cognitive tool that allows students to perceive and solve geometric and visual problems with high efficiency (Lohman, 1996). When gifted students succeed in seeing solutions clearly in their minds SVA and translate this into successful visual achievements in design tasks, these repeated successes directly feed into the first and strongest source of self-efficacy mastery experience (Bandura, 1997; Hammad et al., 2020). Students who feel empowered to manipulate three-dimensional shapes become more confident in their ability to create designs, which is consistent with a study by Al-Zghoul and Al-Dababi (2014) that found a correlation between spatial ability and creative thinking in engineering students. Creativity in engineering design requires visual synthesis, which depends fundamentally on spatial ability. Students with high spatial perception can generate richer and more complex visual variations, which supports the feeling that they are capable of generating unique ideas Cognitive-Affective Interaction. The significance in the context of talent lies in the fact that the correlation $r = 0.48$ confirms that talent development programs should not separate cognitive training SVA from emotional support Cognitive-Affective Interaction. This correlation also supports the thesis of Malizia et al. (2021) on the relationship between specialized cognitive skills and confidence, and provides further evidence that excellence in a specific cognitive domain SVA has a positive transfer effect to the affective domain CSE, in a phenomenon that can be termed self-efficacy enhancement through cognitive specialization.

Third, the results of the simple linear regression analysis Table 3 are among the most important empirical contributions of the current study, as they showed that spatial visualization ability statistically significantly predicts creative self-efficacy $B = 0.49$, $p < 0.001$. This result strongly supports the theoretical model of the study and suggests a clear direction of influence in the relationship between cognitive and affective abilities. The explanatory power is relatively high, with a value of $R^2 = 0.230$ indicating that spatial ability explains approximately 23% of the total variance in creative self-efficacy among gifted students. This percentage is of high practical importance in the context of educational psychology, as it confirms that spatial ability is not merely a technical skill, but rather a fundamental component that nourishes the creative consciousness of gifted students (Karwowski, 2014). The strong standard beta value $B= 0.49$ provides strong evidence of a clear directional effect from the cognitive variable SVA to the affective variable CSE. This can be interpreted as meaning that competence in “spatial thinking” is a prerequisite for building confidence in the ability to “creative design..

If students are unable to visualize the problem, they will not trust their ability to find a creative solution to it. Therefore, spatial training acts as a “cognitive-emotional lever.” This finding supports recent literature on the importance of 21st-century skills, specifically the need to integrate hard and soft skills, as mastery of hard skills SVA enhances confidence and soft skills CSE. This finding is also consistent with the study by (Demetriou et al., 2020), which examined the relationship between cognitive performance and school performance. Based on this in-depth discussion, it can be concluded that the current study has contributed to enriching the literature by confirming the dual and interrelated nature of talent, as it has demonstrated a strong overlap between specialized cognitive ability SVA and affective confidence CSE in gifted students. These findings call for the integration of courses that develop spatial perception into gifted programs, not only to increase technical competence, but also to enhance the affective self-motivation necessary for innovation and entrepreneurship. Methodologically, despite the strength of the descriptive correlational approach, there is a need for further experimental studies using control groups to measure the true causal effect of spatial visualization training on the creative self-efficacy of gifted individuals.

Limitations of the Study

Despite the cognitive and practical contributions made by this study, it is necessary to read and interpret its results in light of certain methodological, statistical, and geographical limitations. The reliance on a descriptive correlational approach was intended to describe the existing relationship without proving causality. Therefore, the predictive power achieved does not necessarily imply a direct causal relationship, which necessitates further empirical studies to verify the actual impact of spatial visualization training on creative self-efficacy. In addition, the study design was cross-sectional, meaning that data was collected at a single point in time. It would have been preferable to use a longitudinal approach to monitor the development of the relationship between spatial and affective abilities as students progressed through various scientific tracks. Statistically, spatial visualization ability SVA was treated as a single variable in the regression analysis, while the literature indicates that this ability has multiple dimensions such as mental rotation and spatial relationships, which limits the analytical depth of the relationship. Sample limitations also mean that the results are restricted to gifted students enrolled in secondary school enrichment programs, making the generalization of the results limited to a select, high-achieving group and not applicable to all public-school students. Finally, although the Revised PSVT: R is a robust standardized tool, the fact that it is a timed test may have affected the performance of some students, along with the reliance of the CSE measure on self-reports, which may be affected by desirable social bias, prompting consideration of incorporating other objective measures of creativity in future research.

Conclusions and Recommendations

In light of the findings obtained through statistical data analysis and in-depth discussion within theoretical and conceptual frameworks, several key conclusions can be drawn. First, the study confirmed that gifted students enrolled in secondary school talent programs demonstrate very high levels of performance in both SVA and CSE, directly supporting the literature that considers these abilities to be distinctive traits of gifted individuals (Wai et al., 2009). Second, the study found a positive and statistically significant correlation between spatial visualization ability and creative self-efficacy ($r = 0.48$, $p < 0.001$), This correlation confirms the close overlap between outstanding cognitive performance and affective confidence in the field of creative idea generation among gifted individuals. Third, spatial visualization ability is a significant and meaningful predictor of creative self-efficacy ($B = 0.49$, $p < 0.001$), explaining approximately 23% of the variance in CSE. This finding represents the main contribution of the study and provides empirical evidence that developing specialized cognitive skills in spatial visualization acts as a “lever” to enhance students' confidence in their ability to be creative and innovative in gifted environments (Sorby et al., 2009). Based on these findings, the study contributes to enriching the literature by providing practical guidance to those responsible for designing talent programs on the priority of integrating spatial training as a basis for enhancing creative awareness. Therefore, based on the results, the study recommends the inclusion of specialized and standardized training modules for the development of spatial visualization SVA into the compulsory courses in talent programs, using 3D computer programs and advanced design models as noted by Bayaga & Kok, (2019), so that these courses are seen as enhancing creative confidence and not merely as a technical skill. In addition, academic advisors should incorporate SVA assessment and CSE measures periodically into comprehensive assessments, directing students toward creative design tasks to enable them to achieve the mastery experience necessary to raise their self-confidence (Bandura, 1997), It is also important to emphasize the need for teachers to provide students with positive and specific feedback that focuses on their success in solving complex spatial problems as evidence of their ability to think creatively and innovatively (Kennedy, 2007). To complement these efforts, a series of future studies are proposed, including conducting experimental studies using control and treatment groups to measure the direct causal effect of an intensive training program on spatial cognition at the CSE level, as well as examining the mediating role of other variables such as spatial anxiety or intrinsic motivation in this relationship, and conducting longitudinal studies to follow the development of the relationship between SVA and CSE and its impact on future professional performance in their scientific specializations.

Author contributions

Author Contributions: Conceptualization: N.A and H.A. Data Collection: N.A and H.A.. Data Analysis: N.A and H.A. Resources: N.A and H.A. Writing—Original Draft Preparation: N.A and H.A. Writing—Review & Editing: N.A and H.A. Funding Acquisition: H.A.

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Institutional Review Board Statement

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. In addition, the protocol for the study was approved by Research Ethics Committee at Najran University.

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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