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THE ROLE OF SPORTS ACTIVITIES IN ENHANCING MATHEMATICS LEARNING AMONG TENTH GRADE STUDENTS IN SOHAR

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ABSTRACT
The study aimed to investigate the role of sports activities in promoting learning of mathematics among tenth-grade students of the public schools in the Sohar Governorate, Sultanate of Oman. It also explored whether perceptions of students were different based on gender as well as the time of the sports lesson was held. To achieve the study's objectives, a descriptive analytical method was employed, and a questionnaire was developed consisting of 27 items grouped in three major dimensions namely cognitive skills, psychological aspects, and social skills concerning the study of mathematics. The questionnaire was distributed to a random sample of 1,006 male and female students enrolled in the tenth grade. The results indicated that students perceive a moderately positive role of physical activities in their mathematics learning, as they contribute to developing mathematical reasoning skills, stimulating memory, reducing anxiety, and increasing social interaction during mathematics classes. Furthermore, statistically significant differences were found regarding the role of physical activities in enhancing mathematics learning, attributed to gender—in favor of male students—and timing of the physical education class, with better results recorded among those who exercised before mathematics class. Based on these findings, the study recommends systematically integrating physical activities into classrooms to support learners' cognitive, emotional, and social development. It also suggests reevaluating the physical education class schedule to improve its academic benefits.

Keywords: Sports activities, mathematics learning, tenth-grade students, cognitive skills, psychological aspects, social skills.

INTRODUCTION

Educational institutions recognize the importance of sports activities due to their role in promoting students' physical, mental, cognitive, and emotional growth (Qatami, 2005). Participation in such activities offers several health, cognitive, social, and psychological benefits. From a health perspective, sports contribute to improving overall health and enhancing physical fitness (Hillman, Erickson, & Kramer, 2008; Ayesh & Muhammad, 2012; Al-Zagbi, 2017; Al-Eizari & Al-Jassas, 2020). Additionally, engaging in sports strengthens students' resilience to academic stress, enhances brain function, and improves concentration (Bayoumi, 2016; Dills, Morgan, & Rotthoff, 2014). Therefore, sports exert a positive influence on cognitive abilities, which is reflected in better academic achievement (Sufyan & Ammar, 2024; Ayesh & Muhammad, 2012; Bilal, 2018; Jalal & Abdul Salam, 2017; Halwani, 2006; Singh et al., 2012; Chih & Chen, 2011; Zach, Shoval, & Lidor, 2016).

From a psychological perspective, engaging in sports activities has a positive impact on improving students' mental health by reducing stress and anxiety levels as well as enhancing mood (Biddle, Mutrie, 2008; Sufyan and Ammar, 2024 It also helps reduce depression and cognitive problems (Hamer & Chida, 2009), enhances self-esteem, increases self-confidence, and promotes psychological balance (Wilson, Sabiston, Mack, & Blanchard, 2012; Ahmed, Abdel-Haq, & Duweikat, 2018; Sufyan & Ammar, 2024). On the social level, practicing sports activities encourages teamwork, helps develop communication and interaction skills, and

enhances control over aggressive behavior and adherence to laws and regulations (Ahmed, Abdel-Haq, & Duweikat, 2018; Al-Walani, 2015).

Mathematics is considered a fundamental subject in education, as it contributes to the development of logical thinking and problem-solving skills (Diab, 2011). Teachers can enhance the learning experience by integrating sports activities into the mathematics curricula, thereby creating an interactive and engaging learning environment. Several studies have demonstrated the effectiveness of using sports-related activities as educational tools to clarify mathematical concepts. By utilizing real sports-related mathematical data, students can perform calculations, prepare graphs, and analyze statistical data (Kautz & Kowalsky, 2021). Initiatives such as "Designing a Playground" and "Organizing a Baseball Team" have proven effective in encouraging students to participate in sports activities that help develop critical thinking, problem-solving skills, and discussion abilities (Turner, Buxner, Miller, Baze, & Valerdi, 2024). Thus, sports activities make mathematics more relatable to students' interests, increasing motivation and engagement in the learning process (Anggraeni & Budiharti, 2021; Kautz & Kowalsky, 2021). A study by Sanchal and Sharma (2017) demonstrated that integrating sports into mathematics learning positively affects various cognitive abilities (Sanchal & Sharma, 2017), enhances focus and attention (Bayoumi, 2016), and contributes to improving the general health condition of students with learning difficulties, which in turn positively reflects on their academic achievement in mathematics (Ghaith, Al-Ziyoud, & Youssef, 2018). Moreover, Carlson et al. (2008) indicated that engaging in sports improves overall academic performance in mathematics.

These diverse positive effects of sports activities create a learning environment that encourages students to overcome educational challenges and enhances their ability to comprehend and concentrate, especially in mathematics, which requires significant mental effort. Based on this, the present study aims to explore the role of participation in sports activities in enhancing mathematics achievement by analyzing its impact on the cognitive, psychological, and social aspects related to mathematics education.

1.1 The study problem

Mathematics is a fundamental subject in educational curricula due to its crucial role in enhancing students' critical thinking and cognitive skills (Diab, 2011). Despite several efforts to improve academic achievement in mathematics, many students continue to face significant learning difficulties (National Mathematics Advisory Panel, 2008; Boaler, 2016; Uwaifo, 2020). These challenges necessitate the exploration of alternative and innovative teaching strategies to enhance learning outcomes. One promising approach is the integration of sports activities into the educational process, which has shown multiple benefits on cognitive, psychological, and social levels (Hillman, Erickson, & Kramer, 2008; Wilson et al., 2012). Numerous studies suggest that incorporating sports activities can help clarify mathematical concepts by connecting learning to practical experience (Sanchal & Sharma, 2017; Carlson et al., 2008). However, limited research has examined this approach within the Omani educational context, particularly at the secondary school level. Therefore, this study addresses this gap by investigating the potential role of sports activities in improving mathematics learning among Omani tenth-grade students.

1.2 The study questions

The present study seeks to answer the main question:"**What is the role of engaging in sports activities in enhancing mathematics learning among eleventh-grade students in Sohar Governorate"?**

This primary question is further divided into the following sub-questions, which aim to analyze this role from cognitive, psychological, and social perspectives:

1. What is the role of engaging in sports activities in enhancing cognitive skills related to mathematics learning among tenth-grade students?
2. What is the role of engaging in sports activities in enhancing psychological aspects during mathematics learning among tenth-grade students?
3. What is the role of engaging in sports activities in enhancing social skills during mathematics learning among tenth-grade students?

1.3 The study assumption

The following hypotheses have been formulated based on the study questions:

1. There are no statistically significant differences between tenth-grade students in Sohar Governorate regarding the role of engaging in sports activities in enhancing mathematics learning based on gender (male, female).

2. There are no statistically significant differences between tenth-grade students in Sohar Governorate regarding the role of engaging in sports activities in enhancing mathematics learning based on the timing of the sports session (before or after the mathematics class).

1.4 Study objectives

The study aims to achieve the following objectives:

1. Explore the role of engaging in sports activities in enhancing mathematics learning among tenth-grade students in Sohar Governorate from cognitive, psychological, and social perspectives.
2. Identify whether there are statistically significant differences between tenth-grade students in Sohar Governorate regarding the role of engaging in sports activities in enhancing mathematics learning based on gender.
3. Determine whether there are statistically significant differences between tenth-grade students in Sohar Governorate regarding the role of engaging in sports activities in enhancing mathematics learning based on the timing of the sports session.

1.5 Significance of the study

The importance of this study lies in its potential to contribute to the existing body of knowledge and deepen the understanding of the relationship between engaging in sports activities and enhancing students' learning in mathematics. This study aims to highlight the positive role that participation in sports can play in improving mathematics learning outcomes. It addresses a significant knowledge gap and provides valuable insights for educators and policymakers regarding the potential benefits of integrating sports into school curricula to enhance mathematics achievement. From a practical perspective, the findings of this study can assist teachers and educational specialists in Oman in developing effective instructional and educational programs. Furthermore, it highlights the importance of incorporating sports activities into the curricula to promote active learning in mathematics. Additionally, the study may offer recommendations for schools and educational institutions to integrate sports activities within their programs and to organize supplementary events that encourage secondary school students to participate actively in sports, thereby supporting the development of both their academic and life skills.

1.6 Delimitations of the Study

- **Objective Delimitation**: This study was limited to exploring the role of engaging in sports activities in enhancing mathematics learning among tenth-grade students in Sohar Governorate, focusing on the cognitive, psychological, and social aspects.
- **Population Delimitation**: The study was conducted on a sample of male and female tenth-grade students in Sohar Governorate.
- **Spatial Delimitation**: The study was confined to secondary schools in Sohar Governorate, Sultanate of Oman.
- **Temporal Delimitation**: The study was conducted during the first semester of the 2023/2024 academic year.

1.7 Terminology of the Study

- **The role** refers to a set of behaviors and expectations that an individual is expected to achieve based on their position or function within a specific social or professional context. It demonstrates through the individual's interaction with others and reflects the responsibilities they assume and the influence they exert (Ghaith, 1979). In this study, the term "role" refers to the extent to which participation in sports activities influences the enhancement of mathematics learning among tenth-grade students. This role is measured through students' responses in the Governorate of Sohar to questionnaire items designed by the researchers, covering three domains: cognitive, psychological, and social.
- **Practice** is defined as the repeated and organized engagement in a specific activity to gain a skill or achieve a behavioral or cognitive goal (Ben Haj & Hemlawi, 2022). In this study, it refers to the structured and regular participation of tenth-grade students in sports activities, whether during classes or breaks, within an educational framework and according to a specific schedule. The aim is to boost students' engagement and motivation to support mathematics learning and enhance classroom interaction and participation.
- **Sports Activities**: According to the dictionary (2004), sports activities are any form of physical exercise performed regularly to develop fitness, health, recreation, or competition. In this study, sports activities refer to a set of exercises, games, and matches included in the physical education curriculum, carried out by tenth-grade students in Sohar under the supervision of the teacher during

physical education classes. These activities aim to develop physical, mental, and social abilities based on defined rules and objectives.

- **Enhancing Mathematics Learning**: According to Al-Ma'ayta (2021), enhancing mathematics learning involves the use of strategies or stimulating environments that help improve students' acquisition of mathematical concepts and skills. In this study, it refers to the improvement in students' understanding of mathematics, as reflected in their responses to questionnaire items within the cognitive domain.
- **Tenth-Grade Students**: This refers to students enrolled in the tenth grade of public schools in the Governorate of Sohar, typically around 15 years of age. This grade represents the beginning of the secondary education stage in the Sultanate of Oman, where the curriculum is general before students specialize in scientific or literary tracks in subsequent years.
- **Sohar Governorate**: A city located in the northern part of the Sultanate of Oman.

LITERATURE REVIEW

Over the past decades, considerable attention has been given to the potential of physical activity to support cognitive, emotional, and academic development in educational settings. Several studies have explored how engaging in structured physical activities, including sports, can contribute to improved learning outcomes, particularly in subjects traditionally perceived as challenging, such as mathematics. Researchers have examined this relationship through various lenses, including academic performance, cognitive functioning, motivation, and student well-being. This review focuses on prior empirical studies that investigated the impact of physical activity, especially sports-based programs on mathematics learning and student achievement. These studies are presented and synthesized in Table 1 below, highlighting their objectives, methodologies, and key findings.

Table 1. Literature review

The study	Study Objective	Sample	Instruments	Findings
Mohamed (2022)	To identify the attitudes of Dar Al Uloom University students toward sports activity based on certain variables	234 students	Questionnaire	Positive attitudes toward sports activity in health, psychological, social, and academic domains. No significant differences by college or academic level, but differences were found based on BMI between students of normal weight, overweight, and obesity.
El-Tantawi (2022)	To explore the benefits of sports activities on general health and academic achievement	327 students	Questionnaire	Sports activities enhance social skills, academic achievement, and self-confidence.
Noor & Hairul (2020)	To measure the impact of integrating physical activity during math lessons on math test performance, short-term memory, and BMI indicators	56 students (age 10)	Digit recall test, math test, BMI, ANOVA analysis	No significant differences in math scores, but physical activity improved memory and reduced BMI. Math results were better in the non-active group.
Hameed & Siddiq (2019)	To examine the impact of physical education on academic skills and achievement	160 students	Questionnaire	Positive effect of physical activity on intelligence, focus, comprehension, time management, verbal communication, and self-confidence. No gender differences

Dapp & Roebers (2019)	Analyze the indirect relationship between physical activity and math achievement through athletic self-concept	102 fourth-grade students	Questionnaire and school math tests	Organized physical activity (more than 2 hours/week) improved self-concept, which led to better math achievement. No gender differences were reported.
Bin Ghaith et al. (2018)	To explore the impact of physical education on academic achievement among students with learning difficulties in math in Kuwait	120 students	Tests	Statistically significant differences favoring the experimental groups (both males and females) who followed an adjusted school schedule. Greater improvement among males with learning difficulties.
Bilal (2018)	To investigate the effect of physical education classes on academic achievement in secondary school	334 students, 13 teachers	Questionnaire	Physical education classes positively affected academic achievement.
Lubans et al. (2018)	To assess the effect of a school-based physical activity intervention on adolescents' math performance	1,173 eighth-grade students	Educational program, test	Slight improvement in math performance. No significant changes in out-of-school activity or gender-based differences.
Jalal & Abdulsalam (2017)	Examine the effect of physical education on academic achievement among fourth-grade middle school students	45 students	Questionnaire	Physical education sessions played an important role in academic achievement.
Sanchal & Sharma (2017)	To study the effect of tenth-grade students' attitudes toward mathematics when taught in a sports-related context	54 students	Questionnaire	Teaching mathematics through sports improved students' confidence, engagement, and awareness of the subject's importance.
Fathi & Mohamed (2016)	To explore the role of sports practice on academic achievement among second-year secondary students	100 students, 6 coaches	Questionnaire	Sports practice had a positive impact on academic achievement.
Al-Shuboul, Qazaqzeh & Jawarneh (2016)	To explore tenth-grade students' perceptions in Irbid about the impact of physical activities on health, psychological, social, and academic development	322 students	Questionnaire	Perceptions were rated "high." Significant gender differences favoring males. No differences by residence or GPA.
Cap (2015)	To assess the effect of weekly sports practice frequency on math performance	1,300 students	Questionnaire	Weak influence of sports activity on mathematics results.

1.8 Discussion of the Literature Review

Most previous studies (Table 1) have consistently indicated the positive impact of physical activity on enhancing academic achievement, particularly in mathematics. Research findings such as those of El-Tantawi

(2022), Hameed & Siddiq (2019), Bilal (2018), and Fathi & Mohamed (2016) have highlighted the role of physical education in improving cognitive abilities, such as increased concentration and faster comprehension, in addition to supporting both academic and life skills.

The current study aligns with several works that examined the relationship between physical activity and learning mathematics, including Noor & Hairul (2020), Dapp & Roebers (2019), Lubans et al. (2018), and Sanchal & Sharma (2017). These studies demonstrated that regular and structured physical activity is often associated with improved performance in mathematics. Some of these studies also explored the mediating variables that contribute to this relationship, such as self-concept (Noor & Hairul, 2020; Dapp & Roebers, 2019) and increased engagement (Sanchal & Sharma, 2017).

However, these findings differ from those of Cap (2015), which reported a weak effect of physical activity on students' academic performance in mathematics. Additionally, the present study shares similarities with Al-Shuboul, Qazaqzeh, & Jawarneh (2016), particularly in exploring tenth-grade students' perceptions regarding the psychological, social, and academic benefits of physical activity. In contrast, it differs from Mohamed (2022), who focused on university students' attitudes toward sports participation in light of selected demographic variables.

Methodologically, the current study also aligns with several previous studies that utilized questionnaires as the primary data collection tool, such as those by Mohamed (2022), El-Tantawi (2022), Hameed & Siddiq (2019), Bilal (2018), and Fathi (2017). However, other studies employed different research methods: Noor & Hairul (2020) used quantitative testing instruments, while Lubans et al. (2018) implemented a large-scale intervention-based design. This variation underscores the methodological diversity in the field, contrasting with the current study's survey-based approach.

Regarding the sample characteristics and educational stages, some studies focused on elementary-level students, such as Noor & Hairul (2020) and Dapp & Roebers (2019). Others targeted middle school students, as seen in Lubans et al. (2018) and Jalal (2017), who examined outcomes among fourth-year students in basic education. Fewer studies have focused on high school students; those that did such as Bilal (2018), Mohamed (2015), and Fathi (2017)—tended to explore the general impact of physical education without a specific focus on mathematics. In this regard, the current study closely resembles that of Sanchal & Sharma (2017), both of which targeted tenth-grade students, although the latter focused on students' attitudes toward mathematics when taught in a sports-based context.

It is also worth noting that some studies included teachers or coaches as part of their sample, such as those by Bilal (2018), Fathi (2017), and Mohamed (2015). Sample sizes varied significantly across studies—from small samples such as Mohamed (2015) with only 30 students, to moderate ones like El-Tantawi (2022) with 327 students and Bilal (2018) with 334 participants, up to large-scale samples such as the one in Lubans et al. (2018), which included over one thousand students—comparable to the current study.

The present research is among the first of its kind in the Sultanate of Oman to the best of the authors' knowledge to investigate the role of physical activity in enhancing mathematics learning, specifically among tenth-grade students in the Governorate of Sohar. This study offers a unique contribution by exploring how sports participation may support students' understanding of mathematical concepts. It also opens new directions for developing integrated teaching strategies and designing class schedules that align cognitive and physical development. Furthermore, this study has benefited from prior literature in selecting appropriate tools and designing its methodology, and it has drawn on previous findings to interpret and contextualize its results—contributing to the advancement of research in this interdisciplinary field.

2 Study Approach

The researchers adopted the descriptive analytical method due to its appropriateness for this type of study, as it allows for a systematic examination of the relationship between physical activity and mathematics learning without manipulating the variables. This approach is widely recognized as suitable for research aiming to interpret and analyze existing educational phenomena (Creswell, 2014).

2.1 The study population and sample:

The study population of interest consisted of tenth-grade students in Sohar, Sultanate of Oman, during the academic year 2023/2024. The total number of students was (2,741) including (1,377) males and (1,364) females. A simple random sample of (1,006) students was selected, representing approximately (36.7%) of the total population. The sample included (457) male students and (549) female students. Participants were categorized based on demographic variables, as illustrated in Table 2. The table also presents students'

preferences regarding the scheduling of physical education (PE) relative to mathematics classes. A majority of students (60.8%) preferred to have PE after the mathematics class, while (39.2%) preferred it before.

Table 2. Characteristic of the study sample

Variable	Category	Frequency	Percentage(%)
Gender	Male	457	45.4
	Female	549	54.6
PE Class Preference	Before the math class	394	39.2
	After math class	612	60.8

2.2 Data collection instrument

To develop the research instrument and achieve the study objectives, a review of relevant literature was conducted, including both Arabic and international studies. Among the Arabic references consulted were the studies of Al-Tantawi (2022), Hameed and Siddiq (2019), Bilal (2018), Fathy (2017), and Jalal (2017), all of which highlighted the educational and psychological benefits of integrating physical activity into the learning process. International research, such as that by Donnelly and Lambourne (2011), Singh et al. (2019), and Fedewa and Ahn (2011), also provided strong evidence of the positive effects of physical activity on students' academic performance and cognitive development particularly in subjects like mathematics. Based on insights drawn from these studies, a structured questionnaire was developed to measure the role of physical activity in enhancing the learning of mathematics among tenth-grade students in Sohar, Sultanate of Oman.

In designing the questionnaire, special attention was paid to the clarity of the items and their relevance to cognitive, psychological, and social dimensions, in order to ensure their appropriateness for the academic and developmental levels of tenth-grade students in the Omani context. The questionnaire consisted of two parts: The first part focused on general demographic information, including gender and students' preferred timing of the physical education class relative to the mathematics class. The second part initially included 24 items distributed across three domains: cognitive, psychological, and social. After being reviewed by experts in education and measurement, and following revisions based on their feedback including the modification and addition of some items the final version of the questionnaire consisted of 27 items. These were formulated using a five-point Likert scale.

2.3 Face validity

To verify the validity of the study instrument, the preliminary version of the questionnaire was presented to a panel of nine experts specialized in education, all members of the academic staff with relevant experience and competence. They were asked to evaluate the appropriateness of the questionnaire items and suggest any modifications or additions. Based on their feedback, necessary adjustments were made, resulting in the final version of the questionnaire consisting of (27)items.

2.4 Internal consistency

The results presented in Table 3 show the Pearson correlation coefficients calculated between the score of each questionnaire item and the total score of its respective domain.

Table 3. Correlation Coefficients

Items	Correlation	Items	Correlation	Items	Correlation
(1)	.615**	(10)	.688**	(19)	.693**
(2)	.687**	(11)	.628**	(20)	.707**
(3)	.690**	(12)	.749**	(21)	.702**
(4)	.603**	(13)	.701**	(22)	.683**
(5)	.613**	(14)	.688**	(23)	.713**
(6)	.731**	(15)	.754**	(24)	.683**
(7)	.705**	(16)	.740**	(25)	.711**
(8)	.619**	(17)	.686**	(26)	.691**
(9)	.662**	(18)	.693**	(27)	.652**

.** Correlation is significant at the 0.01 level (2-tailed)

.* Correlation is significant at the 0.05 level (2-tailed)

2.5 The reliability of the study instrument

Test re-ability was obtained through the use of Cronbach's alpha coefficient. The study tool was completed by a sample of (50) of tenth-grade students in Sohar, Sultanate of Oman in the academic year 2023/2024. Cronbach's alpha coefficient was calculated for the entire questionnaire as well as for each of its domains,

as shown in Table 4. The overall reliability coefficient reached 0.956, indicating a high level of internal consistency that makes the instrument suitable for use in the current study.

Table 4. Reliability of the study instrument

Study topics	Items	The reliability
1	9	.885
2	9	.900
3	9	.913
Sum	27	956

2.6 Study Variables

This study deals with the independent and dependent variables, which are as follows:

- **Independent Variables**: These include gender (male, female) and the timing of the physical education class (before the mathematics class, after the mathematics class).
- **Dependent Variables**: These are represented by the participants' responses to the questionnaire domains (cognitive, psychological, and social), in addition to the total score reflecting the role of practicing sports activities in enhancing mathematics learning among tenth-grade students in the Governorate of Sohar.

2.7 Statistical Analysis

To achieve the objectives of the study, data were analyzed using the Statistical Package for Social Sciences (SPSS), employing the following statistical methods:

1. Pearson correlation coefficient to assess the validity of the study instrument (questionnaire).
2. Cronbach's Alpha to evaluate the internal consistency and reliability of the questionnaire.
3. Means and standard deviations to examine participants' responses to each questionnaire item.
4. Mann–Whitney U test to determine the presence of statistically significant differences at the significance level of ($\alpha \leq 0.05$) between groups according to gender (male, female) and the timing of the physical education class (before or after the mathematics class).

2.8 Classification of responses

The following standard values were adopted to determine the level of responses from the teachers' perspective, as shown in Table 5. This categorization of mean scores into descriptive levels (very high, high, moderate, low, very low) follows common practices in educational research (Best, Kahn, 2006).

Table 5. Standard to determine the level of responses

Response Level	Very Low	Low	Moderate	High	Very High
Mean Score	1-1.80	1.81- 2.60	2.61-3.40	3.41-4.20	4.21-5

2.9 Testing the Nature of the Data

The results of the (Kolmogorov–Smirnov) and (Shapiro–Wilk) tests, presented in Table 6, indicate that the data do not follow a normal distribution. This is evidenced by the p-values being less than the significance level of (0.05) across all domains. Consequently, non-parametric tests will be used for data analysis.

Table 6. Normality Teats

Domain	Shapiro–Wilk			Kolmogorov–Smirnov		
	sig	df	value	sig	df	value
First domain	.000	1006	.981	.000	1006	.051
Second domain	.000	1006	.981	.000	1006	.045
Third domain	.000	1006	.966	.000	1006	.073
Total domains score	.000	1006	.987	.001	1006	.040

STUDY RESULTS

To answer the research questions, means and standard deviations were calculated for each of the study domains. The results are presented in Table 7.

Table 7. Overall mean score across all domains

Rank	Domains	Means	Standard deviations	Degree
1	The role of physical activity in the cognitive domain	3.392	0.890	Moderate
3	The role of physical activity in the psychological domain	3.305	0.973	Moderate
2	The role of physical activity in the social domain	3.310	1.029	Moderate
	Overall	3.336	0.885	Moderate

The results shown in Table 7 indicate that the overall mean score across all domains was moderate, with a mean of 3.336 and a standard deviation of 0.885. Among the three domains, domain 1, the cognitive impact of physical activity recorded the highest mean score (3.392), followed by the social domain (3.310), and finally the psychological domain, which scored the lowest. These findings suggest that tenth-grade students in Sohar demonstrate a moderate level of awareness regarding the role of physical activities in enhancing cognitive aspects of learning mathematics. The researchers attribute these results to the fact that physical activities may not have been explicitly designed or implemented in a way that directly connects them to structured, educational objectives whether cognitive, psychological, or social in the context of mathematics learning.

Although the Ministry of Education in the Sultanate of Oman has shown increased interest in promoting physical activity in schools, in alignment with the national vision "Oman 2040" which emphasizes holistic student development across cognitive, psychological, and social domains physical education in Omani schools remains largely recreational or health-focused, rather than being intentionally integrated into academic learning outcomes, such as supporting mathematics achievement. This tendency may explain why students' perceptions of the role of physical activity in mathematics learning remained within the "moderate" level across all domains. Furthermore, the limited collaboration between physical education teachers and subject teachers may be a contributing factor that restricts the effective use of physical activity as an educational tool in classroom settings. The results for each individual domain are discussed in detail as follows:

2.9.1 First: Results Related to the First Research Question

What is the role of physical activity in enhancing cognitive skills related to learning mathematics among tenth-grade students?

To answer this question, the means and standard deviations were calculated for the items in Domain 1 (Cognitive Skills). The results are shown in Table 8.

Table 8. Means and Standard Deviations for the Cognitive Skills Domain

Items	Mean	Std. Deviation	Rank
1. Practicing physical activities contributes to developing mathematical thinking skills.	3.74	1.069	High
2. Practicing physical activities helps activate my memory.	3.27	1.273	Moderate
3. Practicing physical activities helps me develop skills to solve difficult mathematical problems.	3.21	1.262	Moderate
4. Practicing physical activities helps enhance my understanding of some mathematical concepts.	3.43	1.248	High
5. Practicing physical activities helps me organize mathematical ideas systematically.	3.71	1.176	High
6. Practicing physical activities increases my ability to concentrate when studying mathematics.	3.18	1.280	Moderate
7. Practicing physical activities makes me feel energetic when reviewing math lessons.	3.24	1.278	Moderate
8. Practicing physical activities increases my attention span when studying mathematics.	3.39	1.237	Moderate

9.	Practicing physical activities improves my academic achievement in mathematics.	3.37	1.248	Moderate
Sum		3.39	0.890	Moderate

The results presented in (Table 8) indicate that the role of physical activity in enhancing cognitive skills related to learning mathematics among tenth-grade students in Sohar is at a moderate level, with a mean score of (3.39) and a standard deviation of (0.890). The findings highlight that the most prominent cognitive benefit of physical activity lies in enhancing mathematical thinking skills, with a high mean of (3.74) and a standard deviation of (1.069). Similarly, physical activity was reported to stimulate memory, with a mean of (3.71) and a standard deviation of (1.176), and to improve problem-solving abilities for complex mathematical tasks (mean = 3.43, SD = 1.248). However, items related to concentration (mean = 3.27, SD = 1.278) and attention (mean = 3.21, SD = 1.262) were rated at a moderate level, indicating relatively limited perceived effectiveness in these areas compared to other cognitive skills.

The researchers attribute these findings to the fact that physical activity reduces stress and improves mood, which in turn positively affects attention and focus. Additionally, exercise stimulates blood circulation and increases oxygen flow to the brain, which helps activate memory and higher cognitive functions, enhancing students' ability to retrieve and apply mathematical information more effectively during learning. These results are consistent with the findings of Al-Tantawi (2022), Hameed & Siddiq (2019), and Bilal (2018), who also concluded that physical activity supports cognitive skills such as thinking and memory activation. However, similar to the current study, Noor & Hairul (2020) and Dapp & Roebers (2019) found that while physical activity has a positive effect on mental performance, the extent of its impact varies depending on the specific cognitive variable under study, with focus and attention often showing only moderate improvements. In contrast, the current findings differ from those of Al-Shbool, Qazaqzeh, and Jawarneh (2016), whose study in Irbid Governorate revealed that tenth-grade students perceived the effect of physical activity on scientific (academic) development to be at a high level.

2.9.2 Second: Results Related to the Second Research Question

What is the role of physical activity in supporting psychological aspects during mathematics learning?

To answer this question, the means and standard deviations were calculated for the items in Domain 2 (Psychological Aspects). The results are presented in Table 9.

Table 9. Means and Standard Deviations for the Psychological Aspects

Items	Mean	Std. Deviation	Rank
10. Practicing physical activities reduces my levels of anxiety and stress when studying mathematics.	3.32	1.339	Moderate
11. After engaging in physical activity, I feel great enjoyment while studying mathematics.	3.45	1.276	High
12. Practicing physical activities enhances my positive mood when learning mathematics.	3.22	1.291	Moderate
13. Physical activity helps me control my emotions toward classmates in math class.	3.29	1.305	Moderate
14. Physical activity has taught me relaxation techniques during math exams.	3.44	1.300	High
15. Physical activity increases my motivation to learn mathematics.	3.21	1.285	Moderate
16. Physical activity helps me avoid aggressive behavior toward classmates in math class.	3.26	1.279	Moderate
17. Physical activity builds my self-confidence during math lessons.	3.31	1.310	Moderate
18. Physical activity enhances my endurance and persistence in solving math problems.	3.24	1.361	Moderate
Sum	**3.305**	**0.973**	Moderate

The results presented in Table 9 indicate that physical activity plays a moderate role in enhancing the psychological aspects related to learning mathematics among tenth-grade students in Sohar. The total mean score for this domain was (3.30), with a standard deviation of (0.973).

The role of physical activity was rated high in terms of reducing anxiety and stress when studying mathematics (mean = 3.45) and in increasing enjoyment toward learning mathematics (mean = 3.44). These results reflect the importance of physical activity in preparing students psychologically for academic engagement. Meanwhile, physical activity showed a moderate impact on other important psychological factors, including enhancing self-confidence, acquiring relaxation techniques during exams, increasing motivation, and emotional regulation within the classroom. These aspects are particularly important in a learning environment that demands emotional and psychological balance, especially when tackling abstract and cognitively demanding subjects such as mathematics.

These findings are consistent with previous research such as Bilal (2018), Fathi (2017), and Mohammad (2015), which confirmed that engaging in physical activity contributes to lowering stress levels and enhancing students' sense of comfort and confidence in the classroom, thereby positively influencing their readiness to engage with academic content. The current study also aligns with international findings from Sanchal & Sharma (2017) and Lubans et al. (2018), which indicated that involvement in physical activity increases intrinsic motivation and improves general mood, contributing to more positive attitudes toward learning mathematics. However, some studies such as Noor & Hairul (2020) and Dapp & Roebers (2019) argue that the psychological effects of physical activity are not necessarily direct or uniform. They suggest that factors such as the type, duration, and frequency of activity, as well as individual learner characteristics (e.g., personality traits or levels of math anxiety), may influence outcomes. The positive psychological effects of physical activity may be explained by its ability to regulate emotional responses, release tension, and stimulate neurotransmitters like endorphins, which are associated with mood enhancement. These effects help create a more positive and less stressful learning environment, which is particularly beneficial in cognitively demanding subjects such as mathematics. Nevertheless, the current findings differ from those of Al-Shbool, Qazaqzeh, and Jawarneh (2016), who found that tenth-grade students in Irbid perceived the impact of physical activity on their psychological development to be at a high level, possibly due to differences in context or educational programming.

2.9.3 Third: Results Related to the Third Research Question

What is the role of physical activity in enhancing social skills during mathematics lessons?

To address this question, the means and standard deviations were calculated for the items in domain 3 (Social Skills). The findings are presented in Table 10.

Table 10. Means and Standard Deviations for the Social Skills domain

Items	Mean	Std. Deviation	Rank
19. Physical activity enhances my sense of healthy competition with classmates in math class.	3.29	1.405	Moderate
20. Physical activity has helped me strengthen teamwork during math lessons.	3.34	1.291	Moderate
21. Physical activity has helped me interact more effectively with my math teacher.	3.38	1.296	Moderate
22. Physical activity enhances my cooperation with peers in solving mathematical problems.	3.28	1.315	High
23. Physical activity has helped me integrate more with classmates during math class.	3.44	1.316	Moderate
24. Physical activity has helped me ask classmates for help when I face difficulty solving math problems.	3.31	1.322	Moderate
25. Physical activity develops my time management skills when studying mathematics.	3.26	1.306	Moderate
26. Physical activity encourages me to take initiative and express opinions during math lessons.	3.24	1.335	Moderate
27. Physical activity has helped me respect the opinions of my classmates during math class.	3.24	1.448	Moderate

Sum	**3.310**	**1.029**	Moderate

The results shown in Table (10) indicate that physical activity plays a moderate role in enhancing social skills related to learning mathematics among tenth-grade students in Sohar, with a total mean score of (3.31) and a standard deviation of (1.029). These findings suggest that students perceive physical activity as a contributing factor to improving social interaction within mathematics classrooms both with peers and with teachers. Among the areas with the highest influence, students reported that physical activity enhances: A sense of competition among peers (Mean = 3.44), Teamwork skills (Mean = 3.38), and Interaction with the teacher (Mean = 3.34).These results reflect a moderate positive impact of physical activity in fostering a collaborative and interactive learning environment.

The researchers attribute these findings to the lack of a structured physical education program explicitly linked to mathematics content. In many cases, students engage in general physical activities that are not specifically designed to support interactive classroom learning scenarios. Although physical activity by nature promotes interaction, cooperation, and social relationship-building, its educational potential may remain underutilized unless intentionally integrated into the academic curriculum. Engaging students in movement-based activities provides indirect learning opportunities that support the development of behaviors such as accepting others' opinions, taking initiative, organizing time, and working collaboratively, all of which can reflect positively in the mathematics classroom. Accordingly, these findings underscore the importance of strengthening the social dimension of physical education through more targeted, curriculum-integrated programs, which would enable interactive learning in mathematics and enhance both understanding and student participation.

These results are consistent with the findings of Bilal (2018) and Mohammad (2015), both of which highlighted that physical activity promotes cooperation and team spirit in educational settings. Similarly, the study by Lubans et al. (2018) found that structured physical activity programs contribute to the development of key social skills, including self-regulation, positive interaction, and respect for others.

Moreover, the findings partially align with Sanchal & Sharma (2017), who noted that incorporating physical activities into mathematics instruction increases student engagement and collaboration within classroom groups. However, the current findings differ from those of Al-Shbool, Qazaqzeh, and Jawarneh (2016), which indicated that students in Irbid perceived the social impact of physical activity on learning mathematics at a high level—a variance that could be attributed to contextual or programmatic differences.

The data collected from the study sample is not normally distributed, and therefore the researcher will employ non-parametric tests instead of parametric tests to evaluate the study hypotheses. The Mann-Whitney U Test was conducted based on the variable of (gender and the timing of the physical education class).

2.9.4 Fifth: Results of First Hypothesis

There are no statistically significant differences at the significance level ($\alpha \geq 0.05$) between the mean responses of students regarding the role of physical activity in enhancing mathematics learning attributable to the gender variable (male, female). To test this null hypothesis, the Mann-Whitney U test was employed due to the non-normal distribution of data.

Table 11. The Mann-Whitney U test to the gender variable

Domains	Gender	Mean	standard deviation	Mann-Whitney	Sig
Cognitive domain	Male	3.653	0.860	83721.5	0.000
	Female	3.174	0.856		
Psychological domain	Male	3.627	0.919	79777.5	0.000
	Female	3.037	0.936		
Social domain	Male	3.601	0.940	87023.0	0.000
	Female	3.067	1.037		
Overall	Male	3.627	0.832	78963.5	0.000
	Female	3.093	0.855		

The results of the Mann-Whitney U test presented in Table (11) revealed statistically significant differences at the significance level ($\alpha \leq 0.05$) between the students' mean scores regarding the role of practicing physical activities in enhancing mathematics learning, attributable to the gender variable. These differences favored males across all three dimensions (cognitive, psychological, and social), as well as in the overall score, with an overall mean of (3.627). Males reported a higher mean in cognitive skills (M = 3.653) compared to females (M = 3.174), followed by psychological aspects (M = 3.627 for males versus M = 3.037 for females), and

then social aspects (M = 3.601 for males versus M = 3.067 for females). This indicates that male students perceive the impact of physical activities on learning mathematics more strongly than their female counterparts.These findings are consistent with those of Al-Shboul, Qazaqzeh, and Jawarna (2016), who found statistically significant gender differences favoring males in tenth-grade students' perceptions of the impact of physical activities on developing health, social, psychological, and academic domains in Irbid Governorate.

The researchers attribute these differences to several factors. Males typically participate more in organized or informal physical activities both inside and outside of school, which increases their awareness of the benefits of such activities on their learning. Additionally, some physical activities integrated into school curricula might be designed to align more closely with male interests in terms of type and mode of implementation, thus encouraging greater engagement and awareness of their benefits. Furthermore, psychological and social differences between genders affect how students perceive the impact of sports, with males generally exhibiting higher levels of competitiveness and group involvement in sports environments—factors associated with improved athletic and academic performance, as noted by Lubans et al. (2018) and Noor & Hairul (2020). The variance in effects between genders may be due to differences in the nature of interaction with physical activities, degree of involvement, and prevailing teaching methods in classroom environments.

These results align with those of Bilal (2018) and Fathi (2017), who reported that males show higher levels of engagement with sports programs and their cognitive and psychological effects. Similarly, they partially agree with Sanchal & Sharma (2017), who found that the impact of physical activity on male students' attitudes toward mathematics was more pronounced than for females. Conversely, these findings differ from some studies that reported no significant gender differences, such as Dapp & Roebers (2019), who suggested that the positive impact of physical activity on cognitive performance does not significantly differ between males and females when equitable educational opportunities and support are provided. They also contrast with Phillips, Hannon, and Castelli (2015), who found that the effect of sports activity on mathematics achievement was more pronounced in females than males.

2.9.5 Sixth: Results of the Second Hypothesis

The second hypothesis stated that "there are no statistically significant differences at the $\alpha \leq 0.05$ level between students' perceptions of the role of physical activity in enhancing mathematics learning, attributed to the timing of the physical education (PE) session (before or after the math class)." To test this hypothesis, the Mann-Whitney U test was employed.

Table 12. The Mann-Whitney U test to the timing of the physical education variable

Domains	Mathematics class	Mean	standard deviation	Mann-Whitney	Sig
Cognitive domain	Before	3.561	0.906	97141.5	0.000
	After	3.283	0.862		
Psychological domain	Before	3.516	0.985	95138.5	0.000
	After	3.169	0.941		
Social domain	Before	3.510	0.965	99013.0	0.000
	After	3.181	1.048		
Overall	Before	3.529	0.880	95222.0	0.000
	After	3.211	0.866		

Table 12 presents the results of the Mann-Whitney U test for independent samples based on the timing of the PE session.The results revealed statistically significant differences (p = 0.000) between students who participated in physical activity before the mathematics class and those who did so afterward, across all three dimensions (cognitive, psychological, and social) as well as in the overall scores. Students who engaged in physical activity before their math class reported higher mean scores in cognitive aspects (M = 3.561, SD = 0.906) compared to those who exercised after the math class (M = 3.283, SD = 0.862). Similarly, in the psychological domain, the mean for the "before" group was 3.516 (SD = 0.985) versus 3.169 (SD = 0.941) for the "after" group. For social aspects, the "before" group averaged 3.510 (SD = 0.965) while the "after" group averaged 3.181 (SD = 1.048). The total overall mean also reflected this pattern, with the "before" group scoring 3.529 (SD = 0.880) compared to 3.211 (SD = 0.866) for the "after" group. These findings suggest that the timing of physical activity relative to the mathematics lesson significantly influences students'

perceptions of its benefits on learning, with physical activity performed before the math class perceived as more effective.

These results align with the findings of Lubans et al. (2018), who emphasized that the timing of physical activity can significantly impact academic performance, with exercise performed prior to academic lessons enhancing attention and cognitive engagement. Similarly, Sanchal and Sharma (2017) reported that engaging in physical activity before class positively influences students' attitudes toward the subject and increases their classroom participation.

CONCLUSION

The findings indicate that practicing physical activities plays a moderate role in enhancing cognitive, psychological, and social skills related to learning mathematics among tenth-grade students in Sohar. Specifically, physical activity showed a notable positive effect on mathematical thinking skills, memory stimulation, and problem-solving abilities. Psychologically, it contributed to reducing anxiety and stress while increasing enjoyment and motivation toward mathematics. Socially, it fostered teamwork, cooperation, and competitive spirit within the math classroom. Significant gender differences were observed, with male students perceiving a greater positive impact of physical activity on their mathematical learning across all dimensions compared to female students. This may be attributed to higher male participation and engagement in sports activities. Furthermore, the timing of physical activity sessions influenced students' perceptions; those who exercised before math classes reported stronger cognitive, psychological, and social benefits than those who exercised afterward. These results suggest that scheduling physical activity prior to academic lessons can better prepare students mentally and emotionally for learning. Overall, the study highlights the multifaceted benefits of physical activity in supporting mathematics education and underscores the importance of gender considerations and optimal timing in maximizing these effects.

Recommendations.

1. Integrate physical activities within mathematics education to enhance cognitive skills such as critical thinking, problem-solving, and memory enhancement.
2. Leverage physical activity as a strategic tool to support students' psychological well-being by mitigating anxiety, boosting self-confidence, and enhancing motivation toward learning mathematics.
3. Promote cooperative physical activities to develop social skills, including teamwork, peer and teacher engagement, and active participation in the learning process.
4. Design gender-sensitive sports programs for balanced benefits and engagement for both male and female students.
5. Reconsider the Schedule physical education sessions before math lessons to improve students' concentration and cognitive readiness.
6. Conduct comprehensive experimental research to determine the optimal timing and frequency of physical activity sessions and to evaluate their impact on academic performance across various subjects.

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