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Development of Normative Data for the D2 Attention Test in Athletes from North and Razavi Khorasan Provinces: Differences by Gender, Age and Sport Expertise in Team and Individual Disciplines

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Abstract

Background: The D2 attention test is a tool for assessing attention capacity, particularly in terms of information processing speed and concentration performance. Establishing normative data based on this test can help tailor cognitive training programs to enhance athletic performance according to athletes' specific needs.

Aim: The purpose of the present study was to establish normative data for the D2 attention test among athletes participating in both team and individual sports, with a specific focus on gender, type of sport and .sport expertise.

Martials and Methods: The statistical population of this study included male and female athletes aged 14 to 30 years from individual and team sports in North and Razavi khorasan. The assessment team evaluated 177 athletes via the D2 attention test. Statistical analyses were performed using the Mann–Whitney U test in SPSS version 23. Percentile values were calculated to establish normative reference points for attentional performance.

Results: Percentile ranks were reported for attention indices (information processing speed, errors, attention and focus) by age, gender, sports experience, and sport type.The results indicated no significant differences in information processing speed (P=0.19), error (P=0.31), or attention and focus levels (P=0.99) when analyzed by age. Also no significant differences in information processing speed (P=0.74), error (P=0.87), or attention and focus levels (P=0.68) when analyzed by sports experience. However, gender-based comparisons revealed a statistically significant difference only in the error (P=0.008), with female athletes demonstrating lower mean error scores than their male counterparts.

In addition, comparison between athletes in team and individual sports showed a significant difference solely in the information processing speed (P=0.01); specifically, athletes involved in team sports exhibited higher mean scores in processing speed compared to those participating in individual sports

Conclusion: Key findings indicate that there are notable differences in attention levels between athletes in team sports and those in individual sports, with each group displaying distinct strengths in cognitive processing. These sex differences suggest that male and female athletes may tailor their cognitive training strategies. These results underscore the importance of considering both gender and type of sport when designing programs to increase attention and cognitive performance in athletic contexts.

Keywords: Selective attention, Cognitive performance in athletes, Visual scanning, Mental training in sports.

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1. Introduction

Attention is a key cognitive function that plays a crucial role in various aspects of life, particularly in sports performance. It encompasses the ability to focus on relevant stimuli and avoid distractions, which are essential skills for athletes to maintain concentration and achieve peak performance in competitive events [1]. In sports, mastering concentration is essential. Competitors must often respond rapidly to cues such as rivals' movements and teammates' actions. Enhancing attentional control strategies improves performance by sustaining focus and clarity, which enables rapid decision-making under pressure. This ability also helps athletes adapt swiftly to unexpected situations. Therefore, refining mental skills is essential, as those who effectively manage their focus often excel in competition [2]. As such, cognitive training should be considered as important as physical conditioning in athletic development. The Black and Red Attention Test, standardized in Iran by Bahrami et al. [3] for male and female student athletes, is a screening tool widely used to assess divided and selective attention. It operates within a dual-task paradigm, requiring individuals to manage two streams of information simultaneously.

The D2 Test is one of the most widely recognized international tools for measuring attentional capacity, which refers to an individual's ability to allocate mental resources efficiently to process relevant information while filtering out distractions [4-6]. It can assist coaches in identifying athletes with strong attentional skills, particularly in sports that require rapid information processing and effective decision-making [7]. The D2 Test of Attention provides a more reliable measure of selective attention, which refers to the ability to concentrate on relevant stimuli while suppressing responses to non-relevant information. The test minimizes the influence of motor skills such as hand–eye coordination and writing speed [8]. Studies have shown that the D2 test has strong psychometric properties, including high test-retest reliability and sensitivity to cognitive performance changes under pressure, making it particularly suitable for athletes [9]. During the D2 Test, athletes are required to quickly and accurately scan lines of letters, identifying only those that match a specific visual criterion (e.g., the letter "d" accompanied by two dashes). This task simulates the cognitive demands typical of high-speed sports environments. Furthermore, its design is particularly relevant to sports environments where rapid information processing and visual stimulus responses are crucial [10].

This study aims to develop normative data for the D2 Attention Test among Iranian athletes by considering factors such as age, gender, and type of sport (team vs. individual). This approach provides a more tailored method for evaluating attentional capacity in athletic populations.

The D2 test has been widely used in international sports psychology research to assess selective attention and cognitive performance in athletes across various disciplines [11, 12]. However, despite its global application, a standardized and culturally adapted version of the D2 Test has not yet been developed for Iranian athletes. The D2 Test provides comprehensive and quantifiable measures of attentional capacity. It primarily assesses selective attention and concentration performance under time pressure, making it highly suitable for evaluating attentional efficiency in sports contexts.

The development of normative data for the D2 Attention Test among Iranian athletes can assist coaches in designing training interventions aimed at addressing specific attentional deficiencies, such as improving focus or reducing error rates. Such targeted cognitive training interventions have the potential to enhance both attentional efficiency and overall athletic performance.

Moreover, incorporating cognitive assessments, such as the D2 test, into the athlete development framework signifies a comprehensive strategy in sports training. This study contributes to the field of sports psychology by expanding the range of tools available for assessing and improving athletes' cognitive abilities. It emphasizes the importance of a balanced development strategy that integrates both physical and mental training.

By adapting the D2 test for application with athletes, this study aimed to improve the training methodologies employed by coaches and sports psychologists, thereby facilitating the development of more effective strategies for optimizing attention and performance across various sporting environments. This study aimed to develop normative data for the D2 Attention Test among Iranian athletes from North and Razavi khorasan in both team and individual sports, to provide a culturally relevant reference framework for assessing attentional capacity, with a focus on selective attention, in athletic populations.

2. Methods and Materials

The present study employed a descriptive-comparative design to establish normative data for the D2 Attention Test among Iranian athletes from North and Razavi khorasan. The primary objective was to determine reference values across various demographic subgroups (e.g., age, gender, type of sport, and level of experience) in order to provide benchmarks for attentional performance within athletic populations. The research protocol was ethically reviewed and approved by the Faculty of Sports Sciences at Hakim Sabzevari University.

2.1. Participation

The statistical population of this study included male and female athletes from individual and team sports in North Khorasan and Razavi Provinces. Participants ranged in age from 14 to

30 years old and were categorized into two age groups: those under 18 and those 18 years and older. Athletes were selected from both amateur and semi-professional levels, all of whom were officially registered with local or national sports organizations, ensuring a minimum level of structured training and competition experience. The study covered a variety of individual sports, including badminton, shooting, and martial arts (e.g., karate and taekwondo), and team sports, such as football, volleyball, and basketball. This diversity was considered in the stratified random sampling process to ensure balanced representation across sport types. In this method, the overall population was first divided into distinct subgroups based on relevant variables such as gender (male/female), sport type (individual/team), and level of performance (amateur/semi-professional). Then, participants were randomly selected from each stratum in proportion to the size of that subgroup in the population. This approach was used to enhance the representativeness of the sample and reduce sampling bias. Using the modified Cochran formula, a sample size of 168 people was calculated for a statistical population of 295, with a 95% confidence level [13]. To account for potential attrition, 200 participants were initially selected. However, due to the presence of outliers and test abandonment, the final sample included 177 athletes. Inclusion criteria consisted of athletes with official registration records, while exclusion criteria included test incompletion or performance identified as statistical outliers.

2.2. Instrument

The principal instrument utilized for data collection is the D2 attention test, a paper–and–pencil assessment designed to test three key dimensions. The d2 Test of Attention provides several key performance indicators for assessing selective attention and cognitive processing. First, processing speed refers to the total number of items scanned within the allotted time, reflecting the overall efficiency of cognitive processing. In this test, it is measured by the total number of marked symbols, regardless of accuracy. Second, the error rate evaluates response accuracy and Selective attention and includes both omission errors (failure to identify target items) and commission errors (incorrectly marking non-target items). Third, concentration performance is calculated by subtracting the number of commission errors from the number of correctly identified target symbols. This index reflects the individual's ability to sustain focused attention and resist distractions over time.These indicators comprehensively assess the participant’s selective and sustained attention, cognitive processing speed, and accuracy [5]. This test consists of rows of letters, where the characters "d" and "p" are the most common, mixed with different amounts of dashes. Participants must identify and mark all target letters, especially "d," which they will find accompanied by two dashes, within the

designated time frame. Each test was administered for four minutes [9, 14]. The D2 test has been widely used and validated internationally, providing reliable measures for evaluating attention and cognitive control [5]. In the Iranian context, the test was standardized by Bagheri, showing excellent reliability with a Cronbach's alpha of 0.91 [15].

2.3. Procedure

All participants received a full explanation of the aims and methods of the study before providing informed consent. The D2 test was conducted in a controlled environment, such as a sports facility, to minimize distractions and maintain uniformity across testing sessions. The test was administered both individually and in small groups, with a maximum of five participants, to ensure consistent testing conditions. The participants were given explicit instructions on how to perform the test, which included a brief practice session designed to acclimate them to the test format. Each participant completed the test once, adhering to standardized timing protocols. Participants who failed to complete the test due to misunderstanding the instructions were excluded from the final analysis.

2.4. Statistic

Researchers conducted comparative analyses on variables such as age, gender, sports background, and sport type using the Mann–Whitney U test. Data analysis was performed using SPSS version 23, with a significance level set at $P < 0.05$ for all statistical tests. In addition to comparative analyses, percentile values were calculated to establish normative reference points for attentional performance.

3. Results

The D2 test evaluates three fundamental aspects: the processing speed information, error rate and concentration. Table 1 presents a summary of the descriptive statistics.

Table 1. Descriptive Statistics of D2 Test Scores across Demographic Groups

Group	N	Information processing speed (Mean±SD)	Error (Mean±SD)	Focus and attention (Mean±SD)
Age				
under 18	54	512.70±67.2	46.94±22.4	211.09±34.7
over 18	123	527.72±58.8	50.98±22.95	212.02±33.3
sports experience				
under 5	54	63.13±1.81	20.37±0.63	38.56±1.25
over 5	123	57.06±2.36	17.92±0.77	37.23±2.06
Sex				
Male	109	525.07±62.7	53.20±22.4	209/84±35/04
Female	68	520.04±60.2	44.21±22.35	214.78±31.4
Sport Type				
Individual	63	507.02±48.8	47.97±22.5	204.86±29.1
Badminton	27			
Shooting	16			
Martial arts	20			
Team	114	532/05±66/2	50/73±22/9	215/54±35/5
Futsal	42			
Volleyball	35			

Handball	37

The findings suggest that athletes over 18 years of age achieved higher mean scores in information processing speed, focus, and attention than athletes in other age categories did. Additionally, male athletes committed more errors than did their female counterparts, who exhibited slight improvements in focus and attention scores. Furthermore, compared with those involved in individual sports, athletes engaged in team sports presented elevated scores in both processing speed and focus and attention. The results of the statistical tests for group comparisons are reported in Table 2.

Table 2. Results of the Statistical Tests for Group Comparisons

Comparison	Variable	Test	Z value	P value
Age Group	Information processing speed	Mann–Whitney U	-1.29	0.19
	Error	Mann–Whitney U	-1.007	0.31
	Focus and attention	Mann–Whitney U	-0.003	0.99
Gender	Information processing speed	Mann–Whitney U	-0.45	0.65
	Error	Mann–Whitney U	-2.64	0.008*
	Focus and attention	Mann–Whitney U	-0.68	0.49
Sport Type	Information processing speed	Mann–Whitney U	-2.56	0.01*
	Error	Mann–Whitney U	-0.77	0.43
	Focus and attention	Mann–Whitney U	-1.30	0.19
sports experience	Information processing speed	Mann–Whitney U	Z=-0.32	0.74
	Error	Mann–Whitney U	Z=-0.15	0.87
	Focus and attention	Mann–Whitney U	Z=-0.40	0.68

*$p \leq 0.05$

3.1. Percentile Ranks and Norms

The table presented below summarizes the percentile ranks for the D2 attention test across various demographic categories, gender and type of sport. These normative data can be utilized to evaluate an athlete's attentional performance in comparison to the standardized sample (Table 3).

Table 3. provides a summary of the percentile ranks for the D2 attention test across different demographic groups, including gender and type of sport

Percentile	Group	Information processing speed	Error	Focus and attention
10th	Male	420	90	165
	Female	429	77	183
	Team sports	432	85	173
	Individual sports	434	80	165
	sports experience (under 5)	432	80	177
	sports experience (over 5)	441	83	165
20th	Male	473	76	183
	Female	471	63	186
	Team sorts	473	70	186
	Individual sports	473	70	185
	sports experience (under 5)	475	71	186

	sports experience (over 5)	471	70	183
50th	Male	517	50	209
	Female	518	41	211
	Team sorts	539	48	209
	Individual sports	509	45	210
	sports experience (under 5)	517	47	211
	sports experience (over 5)	518	47	207
80th	Male	593	35	238
	Female	578	23	251
	Team sorts	597	31	257
	Individual sports	546	30	230
	sports experience (under 5)	588	30	239
	sports experience (over 5)	592	30	248
90th	Male	610	27	257
	Female	602	16	260
	Team sorts	612	21	265
	Individual sports	578	19	241
	sports experience (under 5)	608	22	257
	sports experience (over 5)	610	18	260

The percentile ranks serve as a valuable tool for assessing an athlete's performance, providing insight into their standing relative to peers within the same cohort. Specifically, elevated processing speed scores and reduced error counts are indicative of superior attentional performance.

4. Discussion

The present study development normative data for the d2 Test of Attention among athletes Iran from North and Razavi khorasan, evaluating the influence of variables such as age, gender, sports experience, and type of sport on cognitive performance. Descriptive statistics revealed that across all percentiles (10–90), adults aged 18 and older exhibited higher information processing speeds compared to those under 18. However, the Mann-Whitney U test indicated no statistically significant differences in processing speed, error rates, or attention levels between the two age groups ($p > 0.05$). This finding aligns with previous studies, such as Brickenkamp and Zillmer [16] which suggest that cognitive performance on tasks like the d2 Test may stabilize post-puberty due to similar cognitive developmental stages. One possible explanation for this lack of difference is the study's age classification on the basis of cognitive development stages. Since the participants were divided into two groups, post pubertal adolescents (18-) and young adults (18+), Both groups likely shared comparable stages of cognitive development, particularly in selective attention and processing speed, thus minimizing observable differences. This finding is consistent with prior research, such as Rueda et al. [17] which suggests that selective attention stabilizes post-puberty due to advanced cognitive development.

Additionally, the concept of "differential reaction time" could have played a role in these findings. As previous studies have shown, when the response selection process is eliminated, the number of reactions decreases [18, 19]. The d2 test requires participants to quickly and

accurately identify a highly specific visual target (the letter 'd' with two marks) among distractors. Because the task is simple and highly practiced across trials, the response selection process becomes more automatic and less cognitively demanding over time. As a result, any age-related differences in processing speed may be masked, since the task does not place heavy demands on controlled processing or complex decision-making [20].

Although normative data for the d2 Test of Attention in athletes is limited, some studies offer valuable insights. For instance, Türkeri et al. (2019) investigated 78 individual athletes and 58 team athletes, reporting a slight advantage in reaction time among team athletes compared to their individual counterparts [21]. Comparisons with international normative data highlight the potential cognitive benefits of athletic training, with processing speeds slightly above global averages. These findings contribute to the understanding of attention in athletes and underscore the need for further cross-cultural research.

4.1. Gender Differences in Cognitive Performance

The study results indicated that men generally performed better in terms of information processing speed and total error rate than women did. However, with respect to the attention and focus indices, women scored higher. Statistical analysis revealed a significant difference in total errors between genders, with women committing fewer errors than men. These findings align with previous research, such as Silverman (2006), which suggests that men tend to excel in cognitive tasks requiring rapid information processing but often incur more omission errors [22]. In other words, men may prioritize speed over accuracy, potentially overlooking target stimuli, whereas women typically adopt a more cautious and deliberate approach, resulting in higher accuracy but slightly lower processing speed [23, 24].

To better contextualize the findings of the present study, normative data were compared with international research on the d2 Test of Attention. Brickenkamp and Zillmer [16], in their foundational normative work with German young adults, reported notable gender differences, where males generally demonstrated superior processing speed while females exhibited higher accuracy and fewer errors. Moreover, Halpern's [25] comprehensive review on sex differences in cognitive abilities suggests that males tend to outperform females in tasks requiring rapid information processing, whereas females typically show greater precision and attentional control. Collectively, these international findings support the validity of the current study's results and highlight the consistent influence of gender on attentional performance across cultural contexts.

One factor influencing these differences is the impact of educational attainment on cognitive ability. Previous studies have demonstrated that gender gaps in cognitive performance, particularly in processing speed, are more

pronounced at lower education levels and diminish as education increases [26, 27]. Given that the participants in this study were university students with high educational levels, this may have contributed to the reduced gender differences in information processing speed. Additionally, the increased participation of women in social and educational activities in recent years may also explain this shift [28, 29].

4.2. Impact of Athletic Experience on Cognitive Performance

The study examined the role of sports experience and revealed that athletes with more than five years of experience demonstrated slightly better information processing speed, focus, and attention performance than athletes with less experience. However, the Mann–Whitney test did not reveal statistically significant differences between the two groups. This finding can be interpreted through the inverted-U Hypothesis in sports psychology, which suggests that cognitive and motor performance depend on achieving an optimal level of arousal [30]. Since the d2 test is a paper-and-pencil task conducted under relatively low-stimulation conditions, it may not have elicited the necessary arousal level to highlight significant differences between experienced and less experienced athletes.

Furthermore, previous research has shown that sports enhance perceptual–motor skills and information processing [31]. However, in this study, the uniform testing conditions for all participants and the potential lack of motivation to perform at their best might have contributed to the absence of significant differences between experienced and inexperienced athletes.

When comparing our findings to descriptive and normative data from other countries, a similar trend emerges. Studies conducted in Germany, where the d2 test was originally developed, consistently show that attention and processing speed can vary with factors such as motivation and arousal, especially in performance-oriented populations [16]. Similarly, research on adolescent and adult athletes in Canada and the Netherlands has indicated that sports participation may lead to modest improvements in selective attention and visual scanning. However, these improvements are not always statistically significant under standard, low-pressure testing conditions [32, 33]. Future studies could design tests that simulate real-life competitive sports environments to better assess the actual impact of sports experience on cognitive processing.

4.3. Comparative Analysis of Cognitive Performance in Team vs. Individual Sport Athletes

One of the most notable findings of this study was the significant difference in information processing speed between team athletes and individual sport athletes. Compared with their counterparts in individual sports, team sport athletes exhibit faster information processing, fewer errors, and higher attention and focus

scores. These findings align with prior research, which indicates that team sports require rapid decision-making and predictive skills. Effective performance in these sports involves selecting the appropriate action at the right moment, which is influenced by the athlete's ability to process information quickly and accurately [34]. Since these cognitive skills are directly linked to information processing speed, it is unsurprising that team sport athletes excel in this domain. Prior international studies have similarly highlighted enhanced perceptual-cognitive skills in athletes participating in team-based sports environments [35, 36]. Normative data suggest that athletes in team sports tend to develop superior attentional control and information processing abilities, likely due to the constant need to monitor multiple stimuli, such as teammate positions and opponent actions, in real-time. Such cognitive demands are often embedded in the structure of team games, fostering faster and more efficient processing pathways over time [37]. the interactive and supportive nature of team sports enhancing both psychological resilience and cognitive efficiency during competition. The dynamics of team sports foster a sense of cohesion that can mitigate stress, allowing athletes to perform better in high-pressure situations [38]. Since these cognitive skills are directly linked to information processing speed, it is unsurprising that team sport athletes excel in this domain.

These advantages are often not as pronounced in individual sports, where cognitive performance may be more closely tied to internal factors such as focus maintenance, stress management, and self-regulation. studies suggest that individual sport athletes often focus more on emotion regulation and stress management. However, increased arousal levels in competitive settings may negatively impact their performance [39]. Research indicates that individual sport athletes experience a decline in cognitive performance under stress, whereas team sport athletes benefit from social interaction and a competitive environment that enhances their performance [40]. In contrast, several cross-national studies have found that athletes in individual sports place a greater emphasis on emotional regulation strategies, and may be more vulnerable to cognitive decline in high-pressure situations. Findings from research conducted contexts support the notion that arousal and stress can interfere with attention and processing speed in athletes from individual disciplines [41].

Taken together, international normative comparisons reinforce the current findings, suggesting that the type of sport—team versus individual—plays a crucial role in shaping an athlete’s cognitive profile, especially in domains such as information processing, attention, and decision-making under pressure.

5. Conclusions

Overall, the findings of this study demonstrate that the d2 attention test is a reliable and applicable tool for assessing attention and concentration among athletes aged 14 to 30

years from North and Razavi Khorasan provinces, across both team and individual sports. The results reveal significant differences in cognitive performance based on gender and sport type, with female athletes exhibiting lower error rates and team sport athletes demonstrating faster information processing speeds. It is recommended that factors such as test motivation, environmental conditions, and athletes' cognitive characteristics be considered when interpreting results.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

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Ethical considerations

The author has completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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