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Cross cultural adaptation, validity and reliability of the Greek version of the Vividness of Movement Imagery Questionnaire-2 (VMIQ-2)

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Abstract

The VMIQ-2 has been proven a valid and useful psychometric tool to measure the ability of vividness of movement imagery in sports. However, no validity study has been reported in Greek. The purpose of the present study was to examine the validity and reliability of the VMIQ-2 into Greek in adult athletes derived from various sports activities and different athletic levels. The VMIQ-2-GR (n = 160) was examined for translation, construct and discriminant validity, and also for internal consistency and test–retest reliability. CFA did not show acceptable global fit indices and only the index of (x^2/df) showed an acceptable fit. The resulting factors of the EFA highlighted the discrepancy between the Greek version and the original version of the VMIQ-2. The results of the discriminant validity confirmed that the VMIQ-2-GR was well discriminated between subgroups of athletes and, therefore, showed a good discriminant validity. The Cronbach *a* coefficient was excellent at both measurements (> 0.92 in all cases for all factors). The Spearman *rho* correlation coefficients were statistically significant (< 0.001) with values > 0.47. The findings of the VMIQ-2–GR suggest that it is a valid and reliable tool and it can be used by sports psychologists, sports physiotherapists, coaches and researchers who aim to apply MI in the Greek athletic population.

Keywords Motor imagery · VMIQ-2 · Validity · Reliability · Cross-cultural adaptation

1 Introduction

Motor Imagery (MI) is a well-established psychological intervention to promote sports performance, psychological wellness and rehabilitation [1–6]. It has been defined as a cognitive execution of 'movement representation' without an overt movement [7–9]. Various brain structures (e.g. Brodmann field 4,6) are activated during this process as with voluntary movement activation [10]. These Central Nervous System (CNS) structures are responsible for planning and monitoring the execution of movements [10–12]. This would imply that healthy or unhealthy individuals who are unable to move their extremities physically or intentionally can endeavor to stimulate the brain regions responsible for purposeful movements by using MI.

While it is important to examine MI's effectiveness in both healthy and unhealthy individuals, assessing MI could be challenging due to the fact that it is a cognitive process [3, 13]. Therefore, technical equipment such as

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electroencephalography (EEG) or functional magnetic resonance imaging (fMRI) is necessary in order to assess MI process [10, 14–17]. In their study Fardo et al. [18] used EEG in order to evaluate the effect of MI on pain perception levels when healthy individuals had to imagine pleasant/unpleasant images.

Furthermore, the ability to use MI varies between individuals and depends on the type (internal/external) of MI [19–22]. Internal Visual Imagery could classify as first person's perspective, experienced from within as the individual feels like performing an action. External Visual Imagery incorporates the third person's perspective where the individual takes the view of a spectator watching the movements like a performance [23, 24]. Therefore, the ability to use MI and the perspective of its application is of outmost importance in order to assess the influence of MI in various scientific domains. This assessment is usually carried out by using motor imagery questionnaires.

In addition, various imagery questionnaires have been broadly used in order to assess imagery ability. The Movement Imagery Questionnaire-3 (MIQ-3) was based on a 7-point Likert scale where individuals have to imagine predefined movements for upper/lower extremities in 3 perspectives and its reliability was relatively high ($r = 0.83$ for external visual imagery, $r = 0.79$ for internal visual imagery and $r = 0.85$ for kinesthetic visual imagery), [25]. Also, the Kinesthetic and Visual Imagery Questionnaire-KVIQ has been validated on healthy and disabled populations respectively. It was based on a 5-point Likert scale, assessing internal and kinesthetic visual imagery through simple daily movements. Test–retest reliability for healthy individuals was reported as ($ICC = 0.72$–0.81) and for stroke patients it was ($ICC = 0.80$–0.91) while its validity was not assessed [26].

The VMIQ-2 has been proven a valid and useful psychometric tool to measure the ability of vividness of movement imagery in sports [27]. Vividness and controllability are the key characteristics of imagery ability and therefore differences in brain activity were evident during exposure to vivid or nonvivid imagers [27]. The VMIQ-2 has been used by sports psychologists and coaches in order to assess athletes' imagery ability, which could determine the effectiveness of the interventions and could provide information regarding the use of different imagery perspectives and their efficacious effects on athletic performance [4, 28, 29].

Considering that MI is a proven psychological intervention to promote sports performance and rehabilitation in different scientific domains, the lack of Greek versions of MI questionnaires calls for need for a translated version of the VMIQ-2.

The purpose of the present study was to examine the use of VMIQ-2 questionnaire translated into Greek and to assess its validity and reliability in adult athletes from various sports backgrounds and different athletic levels. This will help the potential to improve sports performance and achieve rehabilitation by combining the use of MI and conventional interventions by sports psychologists, sports physiotherapists, coaches, and researchers in the Greek population.

2 Materials and methods

This study was conducted using questionnaires (VMIQ-2-GR) that were classified as either qualitative or quantitative method. Specifically, answers were obtained through closed-ended questions with multiple choice answer options and were analyzed using quantitative methods. This study was accepted by the Ethics Committee of the University of West Attica (No 18030).

2.1 Participants

Overall, one hundred and sixty (160) adult athletes from various sports activities and different athletic levels aged from 18 to 44 (mean age 23.3 ± 6.5) were recruited for the validity and the reliability procedure of the study. One hundred and twenty-one (121) adult athletes participated in the validity procedure and fifty-four (54) adult athletes participated in the reliability procedure respectively. All athletes were volunteers from several sports, such as football, basketball, volleyball, track and field, swimming, tennis, martial arts, dance, gymnastics, weightlifting, and fitness and from various athletic centers located in Athens, Greece. They were recruited from the University of West Attica in Athens, Greece. Invitations were published on the Physiotherapy Department's website, on social media groups and were also sent to local sports clubs.

The inclusion criteria of the study were: (a) age ≥ 18 years old, (b) active athletic training, (c) speaking Greek as the first language, and d) absence of any intellectual disability that may affect the understanding of the questionnaire and the instructions. The exclusion criteria of the study included cases where participants did not answer 2 or more questions of the VMIQ-2. Written informed consent was provided from all participants.

2.2 Procedure

The cross-cultural adaptation of the Greek version of the VMIQ-2 was completed following standard guidelines. Cross-cultural and multinational research indicated the need of access to valid and reliable tools which were cross-validated among different population groups and other languages [30].

2.2.1 Phase 1. Translation

1) Initial translation: Six bilingual translators with Greek as their first language translated the VMIQ-2 into Greek. All 3 were professional physiotherapists, 1 was a registered nurse and 2 were clinical sports psychologists.
2) Synthesis: The 6 initial translations were synthesized to create the first version of the VMIQ-2-GR.
3) Backward translation: This synthesized version was translated back to English from two independent bilingual translators whose first language was English, and who have not reviewed the original English version.
4) Pre-final version: A comparison of the backward translation and the original questionnaire was held by an expert committee in order to end up with the pre-final version of the VMIQ-2-GR.
5) Pilot study: The pre-final version of the VMIQ-2-GR was conducted with fifteen participants from various education levels and backgrounds in order to confirm that they apprehended all the questions.
6) Completion of the final version of the VMIQ-2-GR and initiation of further psychometric evaluation (Appendix).

2.2.2 Phase 2. Psychometric evaluation

The psychometric evaluation included reliability testing with test, retest reliability and internal consistency estimation. Reliability is the ability to reproduce a consistent result across time and space. It is one of the main criteria that determine the quality of an instrument or a tool [31]. Participants who volunteered in the study made an appointment at the Laboratory of Advanced Physiotherapy (https://ladphys.uniwa.gr/en/homepage/) of the University of West Attica. Participants were initially informed about the conductors of the study and the management of their data, and about their rights to withdraw at any point of the study. Subsequently, participants were informed about the completion of the questionnaire, and they had some time to complete it. The duration of the procedure was 20–30 min.

2.3 Outcome measure

The VMIQ-2 is a questionnaire with twelve items and 3 perspectives [External Visual Imagery—(EVI), Internal Visual Imagery—(IVI), and Kinesthetic Visual Imagery—(KVI)]. Participants have to imagine themselves performing twelve imagery items from three different imagery perspectives: [EVI, (3rd person perspective), IVI, (1st person perspective) and KVI, (feeling the movement)]. They also they have to rate the vividness on a five-point Likert scale from 1 (perfectly clear and vivid) to 5 (no image at all) [27].

The VMIQ-2 twelve imagery items are: 1. Walking, 2. Running, 3. Kicking a stone, 4. Bending down to pick up a coin, 5. Running upstairs, 6. Jumping sideways, 7. Throwing a stone into water, 8. Kicking a ball in the air, 9. Running downhill, 10. Riding a bike, 11. Swinging on a rope, 12. Jumping off a high wall. Scores can vary from high (VMIQ-2 score < 26) to low imagery ability (VMIQ-2 score > 36). The VMIQ-2 showed acceptable factorial, concurrent and construct validity [19, 27, 32].

2.4 Psychometric evaluation

2.4.1 Validity

Construct validity was performed in order to assess the degree to which a group of variables really represent the construct being measured. Moreover, discriminant validity was also performed in order to assess the hypothesis that the measurement of the study is not improperly related to different constructs [31].

2.4.2 Reliability

Internal consistency was used in order to estimate the questionnaire's homogeneity and was determined using Cronbach's a [33]. The interclass correlation coefficient (ICC) was used to test the reliability between the initial and the retest results of the VMIQ-2-GR.

2.5 Statistical analysis

All analysis was performed using SPSS v. 26 statistical package (Statistical Package for the social sciences, SPSS Inc., Chicago, IL, USA). P value of < 0.05 was used to denote statistical significance. Construct Validity was analysed with the use of confirmatory factor analysis (CFA) in order to examine if the Greek version of the VMIQ-2 agrees with the 3 factors (EVI, IVI, KVI) of the original revised version of the questionnaire. The following statistical global fit indices were used for the validity assessment of the VMIQ-2-GR: (1) chi square tested the fit of the observed covariance matrix obtained under the constrains of the model x^2/df (degrees of freedom), (2) root mean square error of approximation (RMSEA), (3) goodness of fit index (GFI), (4) adjusted goodness of fit index (AGFI), (5) Tucker-Lewis index (TLI), (6) incremental fit index (IFI), (7) normed fit index (NFI), (8) and comparative fit index (CFI). The accepted values of the fit indices were: $x^2/df < 5$, RMSEA < 0.10, GFI, AGFI, TLI, IFI, NFI, CFI > 0.90. Furthermore, the fit indices which assess the model goodness of fit were: $x^2/df < 3$, RMSEA < 0.08, and GFI, AGFI, TLI, IFI, NFI, CFI > 0.95 [34, 35].

Exploratory factor analysis (EFA) was performed to identify any possible viable factors. Varimax rotation extraction method was performed for all participants in order to determine the factor structure of the 36 items of the VMIQ-2-GR questionnaire. Items with factor loadings of 0.40 or greater were retained. The rest of the items were removed, and factor analysis was repeated until all items included in the analysis met all criteria. Cumulative percentage of variance explained was considered acceptable if it exceeded 60% [36, 37].

Reliability was examined using the internal consistency coefficient of each subscale using Cronbach's a. Test–retest reliability was examined by estimating Spearman's *rho* correlation coefficient scheduled within 1 week (days 0 and 7).

3 Results

3.1 Construct validity of VMIQ-2-GR

One hundred and twenty-one (121) adult athletes from various sports activities and different athletic levels aged from 18 to 44 years old (mean age 23.6 ± 6.7) were recruited for the validity procedure of the study. Seventy-one of them where males (58.7%) and fifty where females (41.3%). Sixty-nine were professional athletes (57%) and fifty-two were amateur athletes (42%). The years of athletic participation were 10 ± 5.3. Athletes participated in different sports such as football (n = 34–28.1%), gymnastics (n = 11–9.1%), volleyball (n = 10–8.3%), basketball (n = 10–8.3%), running (n = 10–8.3%) and the remaining 37.2% (n = 45) came from different sports activities.

3.2 Confirmatory factor analysis (CFA)

The VMIQ-2-GR did not show acceptable fit indices and only the index of (x^2/df) showed an accepted fit (model with 36 questions). Furthermore, taking into consideration the correlation error in the model with the 36 questions, the only index that had an accepted fit was again the ($x^2/df = 3.830$) (Table 1 and Fig. 1).

Two more possible models were investigated. In the first model, the 12 questions for the IVI factor and the 12 questions for the KVI factor of the original VMIQ-2 were merged as they had the highest correlation. The adaptation of the Greek version was not acceptable (Table 1, model with 36 questions taking into account also the correlation error [two factors]). Then, in a second model it was tested whether all 36 questions create one factor. However, the adaptation of the Greek version was not acceptable (Table 1, model with 36 questions also taking into account the correlation error [one factor]).

The correlation coefficients (Pearson's r) between the 3 factors in the confirmatory factor analysis were positive and even statistically significant, which indicates that the 3 factors were highly correlated with each other. They ranged

Table 1 Results of the confirmatory factor analysis of VMIQ-2-GR did not show acceptable fit indices and only the index of (x^2/df) showed an accepted fit (model with 36 questions)

Model-VMIQ-2-GR	x^2	df	x^2/df	RMSEA	GFI	AGFI	TLI	IFI	NFI	CFI
36 Questions	2263.561	591	3.830	0.154	0.584	0.501	0.665	0.714	0.589	0.698
36 questions also taking into account the error of correlations	1352.747	549	2.464	0.110	0.644	0.568	0.740	0.778	0.676	0.773
36 questions also considering correlation error (two factors)	1444.761	551	2.622	0.116	0.748	0.548	0.712	0.753	0.654	0.748
36 questions also considering correlation error (a factor)	1687.478	552	3.057	0.131	0.555	0.463	0.634	0.634	0.596	0.612
Acceptable values			< 5	< 0.10	> 0.9	> 0.9	> 0.9	> 0.9	> 0.9	> 0.9

RMSEA: root mean square error of approximation, GFI: goodness of fit index, AGFI adjusted goodness of fit index, TLI: Tucker-Lewis index, IFI: incremental fit index, NFI: normed fit index, CFI: comparative fit index

between r = 0.73, $p < 0.001$ and r = 0.85, $p < 0.001$. The highest correlation was observed between IVI and KVI factors (r = 0.85, $p < 0.001$) while the lowest correlation was observed between EVI and IVI factors (r = 0.73, $p < 0.001$). The correlation between EVI and KVI was (r = 0.76, $p < 0.001$).

3.3 Exploratory factor analysis (EFA)

Exploratory factor analysis was carried out (Table 2) and confirmed the results of the confirmatory factor analysis. There was a discrepancy between the Greek version and the original version of the VMIQ-2.

The Kaiser–Meyer–Olkin criterion for assessing the appropriateness of the sample size was 0.824, while the minimum limit is 0.70, which indicated that the sample size was acceptable for performing the factor analysis. In addition, the p-value for the Bartlett's statistical test was < 0.001, which indicated that the correlations between the items of the questionnaire allowed the factor analysis to be carried out.

The results of the factor analysis and the loadings of the items that were > 0.40 were presented in Table 2. To determine the number of extracted factors with eigenvalues above 1.00 the scree plot was curved at the position corresponding to the second factor (Fig. 2). The factor analysis revealed 8 factors that explained 74.9% of the variance of the Greek version of the VMIQ-2. The resulting factors indicated the discrepancy between the Greek version and the original version of the VMIQ-2. As shown in Table 2, the 12 questions for the EVI factor corresponded to the 12 questions of the original VMIQ-2. However, the 12 questions for the IVI factor and the 12 questions for the KVI factor of the original VMIQ-2 did not correspond to 2 factors in the Greek version but to 7 different factors.

3.4 Discriminant validity—relationships with demographic characteristics

The relationships between demographic characteristics and scores on the three factors (EVI, IVI, KVI) of the VMIQ-2-GR questionnaire revealed statistically significant relationships between the 2 genders (Mean: 27.9, SD: 9.3 for males and Mean: 23.9, SD: 9.2 for females) where males had a higher score on the EVI factor than women ($p = 0.02$, $p < 0.05$). The scores on the IVI factor (Mean: 21.6, SD: 8.5 for males and Mean: 21, SD: 7 for females, $p = 0.66$) and also on the KVI factor (Mean: 23.1, SD: 8.7 for males and Mean: 21.3, SD: 8.1 for females, $p = 0.25$) did not reveal statistical significant relationships between the 2 genders. Also, the comparison between subgroups within the sample revealed that professional athletes had significantly higher use of IVI than amateur athletes (Mean: 21.1, SD: 8.5 for professional athletes and Mean: 21.7, SD: 7.1 for amateur athletes). The use of EVI was (Mean: 26.8, SD: 9.8, Mean: 25.5, SD: 9) and the use of KVI was (Mean: 22.4, SD: 9, Mean: 22.4, SD: 7.7) for professional and amateur athletes respectively.

3.5 Reliability of the Greek version of the VMIQ-2

Fifty-four (54) adult athletes from different athletic backgrounds and sports activities aged from 19 to 43 years old (mean age 22.9 ± 6.1) were recruited for the reliability procedure of the study. Thirty of them were males (55.6%) and twenty-four
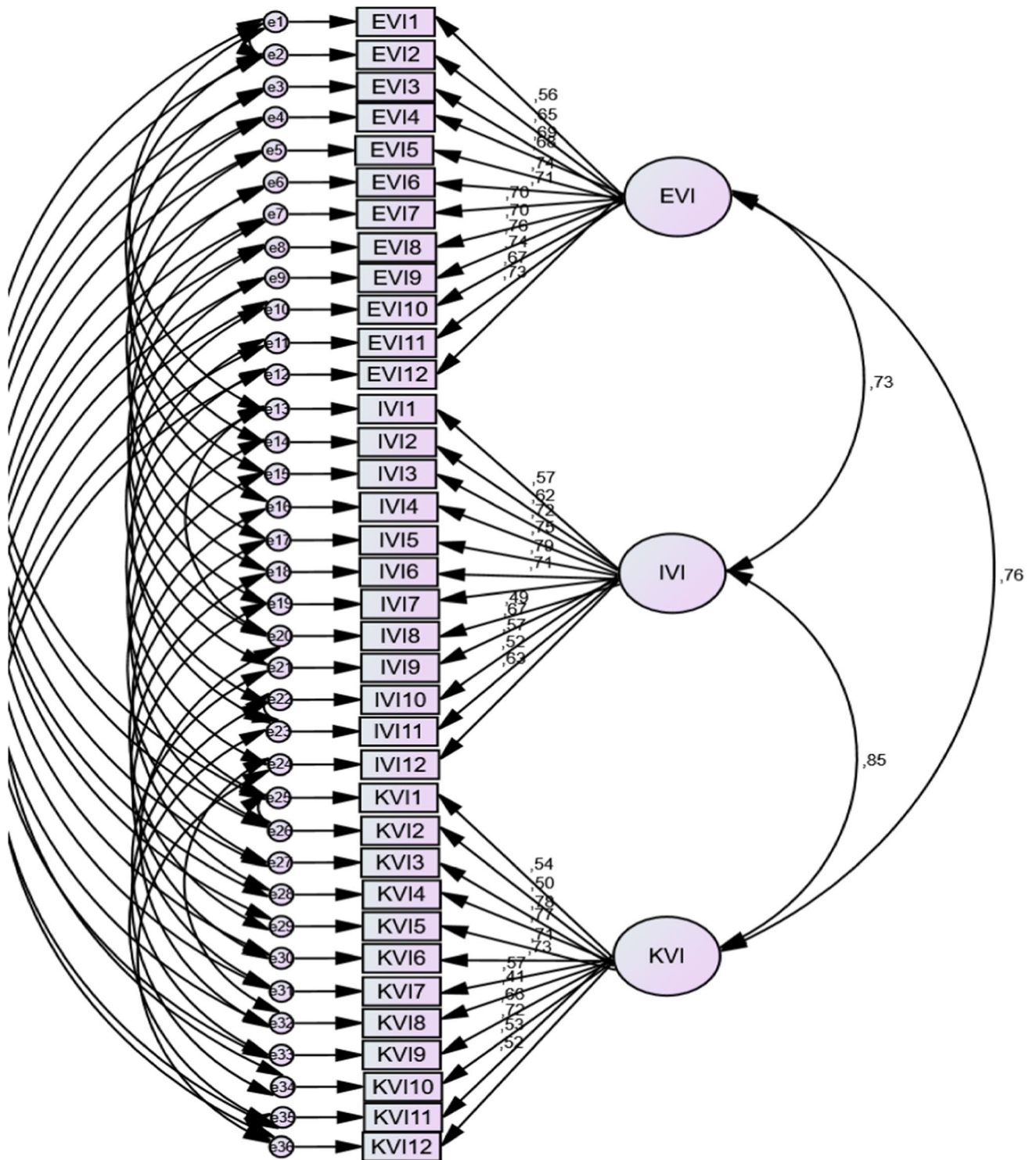
Fig. 1 Confirmatory factor analysis of the Greek version of the VMIQ-2. The correlation coefficients between the 3 factors (EVI, IVI, KVI). Circles containing an 'e' are error variances

Table 2 Exploratory factor analysis of the Greek version of the VMIQ-2 revealed 8 factors that explained 74.9% of the variability

36 Questions	Mean	Standard deviation	Factors							
			1	2	3	4	5	6	7	8
EVI1	1.87	0.88	0.60							
EVI2	1.92	1.00	0.78							
EVI3	1.95	1.00	0.58							
EVI4	2.00	0.96	0.59							
EVI5	2.05	1.09	0.65							
EVI6	2.28	1.01	0.51							
EVI7	2.09	1.02	0.49							
EVI8	2.04	1.09	0.55							
EVI9	2.19	1.08	0.70							
EVI10	2.29	1.20	0.57							
EVI11	2.94	1.24	0.61							
EVI12	2.55	1.32	0.62							
IVI1	1.42	0.78				0.78				
IVI2	1.46	0.77				0.57				
IVI3	1.81	1.01		0.70						
IVI4	1.72	0.83							0.53	
IVI5	1.75	1.00							0.70	
IVI6	1.97	0.98			0.64					
IVI7	1.75	0.93		0.70						
IVI8	1.67	0.92								0.63
IVI9	1.79	0.91							0.68	
IVI10	1.71	0.95			0.75					
IVI11	2.25	1.27					0.56			
IVI12	1.98	1.26					0.79			
KVI1	1.44	0.91				0.86				
KVI2	1.47	0.96				0.87				
KVI3	2.05	1.29		0.71						
KVI4	1.95	1.08		0.55						
KVI5	1.71	0.95								0.52
KVI6	1.93	1.05			0.62					
KVI7	1.86	1.02		0.76						
KVI8	1.72	0.93							0.82	
KVI9	1.66	0.91								0.70
KVI10	1.86	1.02			0.65					
KVI11	2.54	1.34			0.58					
KVI12	2.09	1.15					0.78			

(44.4%) were females. Of those, 81.5% played at amateur level and 18.5% played at professional level. The mean number of years practicing sports was 5.6 (standard deviation = 4.5).

The Cronbach a interclass coefficient correlation at the test and at the retest phase and the intraclass correlation coefficients (ICC) for each factor of the questionnaire were presented in Table 3. The Cronbach a coefficient was excellent at both measurements (> 0.92 in all cases for all factors). Also, for all factors intraclass correlation coefficients were statistically significant ($p < 0.001$) and with values greater than 0.87. All intraclass correlation coefficients were greater than 0.87, so the reliability of the VMIQ-2-GR questionnaire was excellent.

The Spearman rho correlation coefficients between the test and the retest phase for each question were presented in Table 4. For all questions the Spearman rho correlation coefficients were statistically significant ($p < 0.001$) and
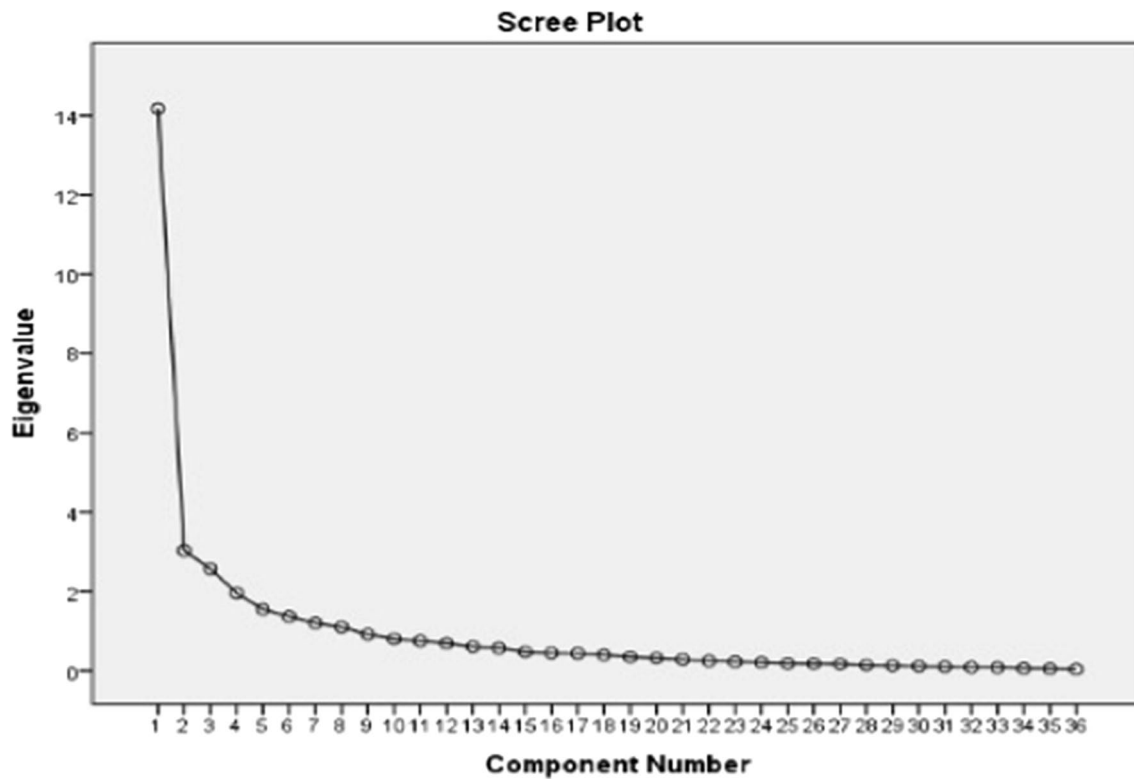
Fig. 2 Scree plot and the Eigenvalues > 1.00 of the exploratory factor analysis of the Greek version of the VMIQ-2

Table 3 Cronbach *a* and the intraclass correlation coefficients—ICC in test, retest reliability for each factor of the VIMQ-2-GR questionnaire were statistically significant

Factors of the VMIQ-2GR	Cronbach *a* at test phase	Cronbach *a* at retest phase	ICC	95% CI	P-value
EVI	0.92	0.95	0.89*	(0.81–0.94)	< 0.001
IVI	0.95	0.96	0.92*	(0.86–0.95)	< 0.001
KVI	0.95	0.96	0.87*	(0.78–0.93)	< 0.001

CI: confidence interval; ICC: intraclass correlation coefficient

*Statistically Significant

To determine test–retest reliability, ICC of the subscales were calculated. In order to assess internal consistency, Cronbach's α was calculated. Values of Cronbach's α that are higher than 0.7 indicate evidence of internal consistency

with values greater than 0.47. We concluded that for all 36 questions a moderate to strong correlation (from 0.47 to 0.83) was shown between test and retest phases and therefore the reliability of the questionnaire was excellent.

4 Discussion

The aim of the present study was to perform a cross-cultural adaptation of the Greek version of the "Vividness of Movement Imagery Questionnaire-2" (VMIQ-2-GR) and to test its validity and reliability. The VMIQ-2 is a simple self-reported imagery tool measuring the vividness of MI mostly in the sports population and it encompasses 3 different types of visual imagery: External Visual Imagery (EVI), Internal Visual Imagery (IVI), and Kinesthetic Visual Imagery (KVI) [19, 27]. Construct validity procedure showed that the measurement of MI ability with the use of VMIQ-2 may

36 Questions of the VMIQ-2-GR	Spearman *rho* correlation coefficient	*P* value
EVI1	0.69	<0.001
EVI2	0.75	<0.001
EVI3	0.60	<0.001
EVI4	0.49	<0.001
EVI5	0.63	<0.001
EVI6	0.52	<0.001
EVI7	0.75	<0.001
EVI8	0.70	<0.001
EVI9	0.59	<0.001
EVI10	0.62	<0.001
EVI11	0.65	<0.001
EVI12	0.56	<0.001
IVI1	0.72	<0.001
IVI2	0.83	<0.001
IVI3	0.63	<0.001
IVI4	0.54	<0.001
IVI5	0.47	<0.001
IVI6	0.73	<0.001
IVI7	0.55	<0.001
IVI8	0.47	<0.001
IVI9	0.66	<0.001
IVI10	0.51	<0.001
IVI11	0.63	<0.001
IVI12	0.49	<0.001
KVI1	0.55	<0.001
KVI2	0.61	<0.001
KVI3	0.63	<0.001
KVI4	0.58	<0.001
KVI5	0.56	<0.001
KVI6	0.59	<0.001
KVI7	0.56	<0.001
KVI8	0.77	<0.001
KVI9	0.66	<0.001
KVI10	0.48	<0.001
KVI11	0.73	<0.001
KVI12	0.65	<0.001

Table 4 Spearman rho correlation coefficients for each question between the test and retest procedures of the VMIQ-2-GR were statistically significant ($p < 0.001$) and with values greater than 0.87

not be equivalent across different cultures (Greek and British). Initially, the results from the British sample revealed that the revised version of the VMIQ-2 supported the 3 factors (EVI, IVI and KVI).

In our study, the results of the Confirmatory Factor Analysis (CFA) did not show acceptable global fit indices and only the index of (x^2/df = 3.830) showed an acceptable fit (model with 36 questions) (Table 1). The high correlation between IVI and KVI values in the CFA, suggest that there may be different patterns of imagery use in athletes'. Our findings are consistent with the research of Callow and Roberts, [19] who aimed to investigate the imagery perspective preference and the order of the IVI and KVI experience. The results of their study revealed that one hundred and fifty nine athletes experienced the imagery perspectives concurrently significantly more often than either the IVI and then the KVI [19]. On the contrary, Callow and Hardy, [38], showed a positive correlation between the use of IVI and KVI ability and the use of EVI and KVI ability. Their findings revealed contradicting results regarding the relationship

between EVI and KVI where the latter combination seemed to be effective on tasks that are mainly dependent on a mentally successful form creation. However, their findings did not support the view that EVI was easier to perform in combination with KVI [38].

Our findings regarding the Exploratory Factor Analysis (EFA) of the VMIQ-2-GR indicated that the data fit the model with 1 of the 3 factors (EVI) of the VMIQ-2. (Table 2). The loadings of the items were > 0.40 and the procedure revealed 8 factors that explained 74.9% of the variance of the Greek version of the VMIQ-2. While the resulting factors indicated a discrepancy between the Greek version and the original version of the VMIQ-2 (3 factors), these findings supported the view that the 8-factor structure of the VMIQ-2-GR had acceptable values. These findings were unexpected since the VMIQ-2 was tested (construct validity) and proven to be valid in Germany which is also a European country [28]. Although, the VMIQ-2 revealed an excellent fit of the 3 factors in Germany, the sample size was two hundred and fifty-four nonathletic student participants whereas our study only included athletes.

Moreover, the original VMIQ consisted of 2 factors and the revised version of the VMIQ-2 was adapted with 3 factors (KVI was added) [27]. The findings of the EFA in our study indicated that the KVI factor could be confusing for most of the participants because the responses between the IVI and the KVI factors had the highest correlation and therefore, athletes could not possibly distinguish IVI and KVI.

In our study, discriminant validity was tested through the relationships between demographic characteristics. The results showed that men had a statistically significant higher score on the EVI factor than women, which confirms that the VMIQ-2-GR was well discriminated between subgroups of athletes, indicating that there were differences between genders and, therefore, showing good discriminant validity.

The comparison between different groups within the sample revealed that professional athletes had significantly higher use of IVI than amateur athletes. These findings are in agreement with previous research where Hardy and Callow [39], investigated external and internal visual imagery on performance in professional athletes. They found that IVI was more effective when the athlete was more experienced thus enhancing sports performance [39]. Also, Olsson et al. [23], in their study investigated the effects of IVI on professional high jumper's performance and the results of the intervention procedure revealed that the application of IVI increased sports performance compared to a regular physical training program.

Furthermore, the VIMQ-2-GR was also proven valid by the face validity procedure. Our findings revealed that athletes answered the questions in an appropriate manner in relation to the Greek language, the level of the Greek language, the terminology, and the understanding of the athletes. All the athletes reported a good understanding of the VIMQ-2-GR which was easy for completion except for the KVI factor which was in accordance with our results. This factor should be further investigated.

Reliability of the translated version of the VMIQ-2-GR showed a statistically significant result. The Cronbach a interclass coefficient correlation (ICC) at the test and retest phase (days 0 and 7) were presented in Table 3. The Cronbach a coefficient was excellent at both measurements (> 0.92 in all cases for all factors). Overall, the reliability of the VMIQ-2-GR questionnaire was strongly positive. The Spearman rho correlation coefficients were statistically significant and with values greater than 0.47. For all 36 questions, a moderate to strong correlation (from 0.47 to 0.83) was shown between the test and retest phases and, therefore, the reliability of the questionnaire was strongly positive (Table 4.) These findings are in agreement with the study of Ziv et al. [40], who examined the reliability of the VMIQ-2 in Hebrew (Cronbach a – [test phase] was 0.91, 0.95 and 0.94, [retest phase] was 0.94, 0.94, 0.95) [40]. However, in their reliable results the correlations were moderate whereas in our study all 36 questions had a moderate to strong correlation.

4.1 Clinical implications

The present study has important clinical implications for several reasons. It is the first study to create a cross-cultural adaptation of the VMIQ-2 into Greek and therefore makes it valuable in terms of research and in the clinical application of MI. Our findings proved the questionnaire to be a valid and reliable self-reported instrument in the sports field for those who desire to assess the vividness and the controllability of MI. The use of the VIMQ-2-GR will aid researchers to introduce the exploration of the effects of MI in Greek sports populations, specifically in the aspects of sports psychology, sports performance and sports rehabilitation. Furthermore, the VMIQ-2-GR could be the tool of choice for sports psychologists,

sports physiotherapists and coaches in order to implement the MI as a complementary therapeutic modality combined with their existing approaches.

4.2 Limitations

The lack of validated instruments in the Greek language to approach the MI or similar psychological concepts made it impossible to compare the VMIQ-2-GR with other instruments (e.g., MIQ-3). Therefore, construct validity, discriminant validity and reliability were performed and proved the VMIQ-2-GR as a valid and reliable questionnaire. The sample size of the current study was acceptable for performing the factor analysis, but it could have influenced the results. On the other hand, the CFA did not show acceptable global fit indices and only the index of (x^2/df) showed an accepted fit (x^2/df = 3.830), whereas discriminant validity was proven good. All participants in the present study were athletes from different athletic levels and athletic backgrounds. Future research could examine the VMIQ-2-GR in a larger sample size and also in various population subgroups with a non-athletic background in order to further explore the cross-cultural differences between the Greek and British populations.

5 Conclusions

In conclusion, the findings of the Greek version of the VMIQ-2 suggest that it is a valid and reliable questionnaire and that it can be used by sports psychologists, sports physiotherapists, coaches and researchers who aim to apply MI in the Greek athletic population.

Declarations

Ethics approval and consent to participate This study was accepted by the Ethics Committee of the University of West Attica (No 18030).

Informed consent Informed consent was obtained from all subjects involved in the study.

Competing interests The authors declare no conflict of interest.

Appendix

Ερωτηματολόγιο Απεικόνισης της Νοερής Κίνησης – 2

Όνομα: **Ηλικία:**

Γένος: **Άθλημα:**

Αθλητικό επίπεδο (π.χ. ερασιτεχνικό, όμιλος/λέσχη, πανεπιστήμιο, εθνικό, διεθνές, επαγγελματικό):

Έτη συμμετοχής σε ανταγωνιστικό επίπεδο:

Η νοερή κίνηση αναφέρεται στην ικανότητα να μπορεί να φανταστεί κάποιος την εκτέλεση μιας κίνησης χωρίς να την πραγματοποιήσει. Στόχος αυτού του ερωτηματολογίου είναι να προσδιορίσει τη ζωηρότητα της απεικόνισης της νοερής κίνησης για την οποία καλείστε να εφαρμόσετε. Οι μετρήσιμοι παράγοντες του ερωτηματολογίου έχουν σχεδιαστεί για να φέρνουν στο μυαλό σας ορισμένες εικόνες. Καλείστε να αξιολογήσετε το βαθμό της ζωηρότητας της κάθε απεικόνισης μέσω μίας κλίμακας 5 σημείων.

- Η πρώτη στήλη αφορά την απεικόνιση μίας εικόνας παρακολουθώντας τον εαυτό σας να εκτελεί την κίνηση από μια εξωτερική οπτική γωνία (Εξωτερική οπτική απεικόνιση).
- Η δεύτερη στήλη αφορά την απεικόνιση μίας εικόνας από μια εσωτερική οπτική γωνία, σα να βλέπετε την εκτέλεση της κίνησης μέσα από τα δικά σας μάτια (Εσωτερική οπτική απεικόνιση).
- Η τρίτη στήλη αφορά την απεικόνιση μίας κίνησης κατά την οποία νιώθετε ότι εσείς οι ίδιοι την εκτελείτε χρησιμοποιώντας όλες σας τις αισθήσεις (Κιναισθητική απεικόνιση).

Προσπαθήστε να εκτελέσετε το κάθε είδος απεικόνισης ξεχωριστά, ανεξάρτητα από τον τρόπο που έχετε εκτελέσει την απεικόνιση κάποιας άλλης στήλης.

Συμπληρώστε όλες τις κινήσεις του ερωτηματολογίου **πρώτον**, διαμέσου της εξωτερικής οπτικής απεικόνισης και στη συνέχεια επιστρέψτε στην αρχή και **δεύτερον** να εκτελέσετε τις ίδιες κινήσεις διαμέσου της εσωτερικής οπτικής απεικόνισης. Ακολούθως, επιστρέψτε στην αρχή και **τρίτον** να εκτελέσετε τις ίδιες κινήσεις διαμέσου της κιναισθητικής απεικόνισης.

Οι τρεις βαθμολογίες για την απεικόνιση μίας κίνησης μπορεί να μην είναι ίδιες σε όλα τα είδη νοερής απεικόνισης. **Παρακαλείστε να έχετε τα μάτια σας ΚΛΕΙΣΤΑ κατά την εκτέλεση όλων των κινήσεων.**

ΟΔΗΓΙΕΣ

Σκεφτείτε καθεμία από τις ακόλουθες κινήσεις που εμφανίζονται στην επόμενη σελίδα και ταξινομήστε τις εικόνες σύμφωνα με τον βαθμό διαύγειας και ζωηρότητας όπως φαίνεται στην ΚΛΙΜΑΚΑ ΒΑΘΜΟΛΟΓΗΣΗΣ.

ΚΛΙΜΑΚΑ ΒΑΘΜΟΛΟΓΗΣΗΣ. Η εικόνα που προκαλείται από κάθε κίνηση μπορεί να είναι:

Απόλυτα καθαρή και τόσο ζωντανή (όπως στην κανονική όραση ή στην πραγματική αίσθηση της κίνησης) ……….. ΒΑΘΜΟΛΟΓΙΑ 1

Καθαρή και αρκετά ζωντανή   ……….. ΒΑΘΜΟΛΟΓΙΑ 2

Μέτρια καθαρή και ζωντανή   ……….. ΒΑΘΜΟΛΟΓΙΑ 3

Αόριστη και αμυδρή   ……….. ΒΑΘΜΟΛΟΓΙΑ 4

Καμία εικόνα, το μόνο που «γνωρίζεις» είναι ότι σκέφτεσαι την κίνηση   ……….. ΒΑΘΜΟΛΟΓΙΑ 5

Κίνηση	1. Παρακολουθώντας τον εαυτό σας να εκτελεί την κίνηση (Εξωτερική οπτική απεικόνιση)					2. Κοιτάζοντας μέσα από τα δικά σας μάτια ενώ εκτελείτε την κίνηση (Εσωτερική οπτική απεικόνιση)					3. Νιώθεις τον εαυτό σου να εκτελεί την κίνηση (Κιναισθητική απεικόνιση)				
	Απόλυτα καθαρή και ζωντανή εικόνα όπως η κανονική όραση	Καθαρή και αρκετά ζωντανή εικόνα	Μέτρια καθαρή και ζωντανή εικόνα	Αόριστη και αμυδρή εικόνα	Καμία εικόνα, το μόνο που «γνωρίζεις» είναι ότι σκέφτεσαι την κίνηση	Απόλυτα καθαρή και ζωντανή εικόνα όπως η κανονική όραση	Καθαρή και αρκετά ζωντανή εικόνα	Μέτρια καθαρή και ζωντανή εικόνα	Αόριστη και αμυδρή εικόνα	Καμία εικόνα, το μόνο που «γνωρίζεις» είναι ότι σκέφτεσαι την κίνηση	Απόλυτα καθαρή και ζωντανή εικόνα όπως η κανονική όραση	Καθαρή και αρκετά ζωντανή εικόνα	Μέτρια καθαρή και ζωντανή εικόνα	Αόριστη και αμυδρή εικόνα	Καμία εικόνα, το μόνο που «γνωρίζεις» είναι ότι σκέφτεσαι την κίνηση
1. Περπατάω	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2.Τρέχω	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3. Κλωτσάω μια πέτρα	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4. Σκύβω να πιάσω ένα κέρμα	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5. Ανεβαίνω τις σκάλες τρέχοντας	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
6. Κάνω άλματα στο πλάι	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
7.Πετάω μία πέτρα στο νερό	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
8.Κλωτσάω μια μπάλα στον αέρα	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
9.Τρέχω στην κατηφόρα	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
10. Οδηγώ ένα ποδήλατο	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
11. Αιωρούμαι σε ένα σχοινί	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Κίνηση	1. Παρακολουθώντας τον εαυτό σας να εκτελεί την κίνηση (Εξωτερική οπτική απεικόνιση)					2. Κοιτάζοντας μέσα από τα δικά σας μάτια ενώ εκτελείτε την κίνηση (Εσωτερική οπτική απεικόνιση)					3. Νιώθεις τον εαυτό σου να εκτελεί την κίνηση (Κιναισθητική απεικόνιση)				
	Απόλυτα καθαρή και ζωντανή εικόνα όπως η κανονική όραση	Καθαρή αρκετά ζωντανή εικόνα	Μέτρια καθαρή και ζωντανή εικόνα	Αόριστη και αμυδρή εικόνα	Καμία εικόνα, το μόνο που «γνωρίζεις» είναι ότι σκέφτεσαι την κίνηση	Απόλυτα καθαρή και ζωντανή εικόνα όπως η κανονική όραση	Καθαρή αρκετά ζωντανή εικόνα	Μέτρια καθαρή και ζωντανή εικόνα	Αόριστη και αμυδρή εικόνα	Καμία εικόνα, το μόνο που «γνωρίζεις» είναι ότι σκέφτεσαι την κίνηση	Απόλυτα καθαρή και ζωντανή εικόνα όπως η κανονική όραση	Καθαρή αρκετά ζωντανή εικόνα	Μέτρια καθαρή και ζωντανή εικόνα	Αόριστη και αμυδρή εικόνα	Καμία εικόνα, το μόνο που «γνωρίζεις» είναι ότι σκέφτεσαι την κίνηση
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
12. Πηδώ από ένα ψηλό τοίχο						1w	2	3	4	5	1	2	3	4	5

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