Development and Psychometric Properties of the Sport Imagery PETTLEP Inventory (SIPI)

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Abstract

PETTLEP is an evidence-based applied model of imagery thought to allow athletes to practice vivid images. The present article aims to develop and evaluate psychometric properties of a PETTLEP-based instrument that measures athletes' ability to image according to this model. Study 1 had 2 specialists and 283 amateur athletes. Inter-rater reliability was moderate (κ = .54), internal consistency was high (α = .92) and scale's number of items were cut by half using asymmetry, item-to-total correlation and differential item functioning as criteria. Volunteers of Study 2 were 322 elite athletes. Exploratory factor analysis revealed a single factor, whereas confirmatory factor analysis confirmed a hierarchical first-order structure with one higher factor. Convergent validity was assessed showing moderate correlation between the proposed measure and another imagery instrument (r = .54). The new instrument showed good psychometric properties and it reveals to be a reliable measure to assess imagery under PETTLEP approach.

KEYWORDS: imagery, PETTLEP, psychometrics, sport.

Desenvolvimento e Propriedades Psicométricas do Inventário de Esportes de Imagética PETTLEP (IEIP)

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Resumo

PETTLEP é uma abordagem baseada em evidências pensada para permitir atletas a praticar imagens mentais vívidas. O presente artigo objetiva desenvolver e avaliar as propriedades psicométricas de um instrumento baseado na PETTLEP que mensura a habilidade de atletas em usar imagens mentais de acordo com esse modelo. Estudo 1 teve 2 especialistas e 283 atletas amadores. Confiabilidade inter-observadores foi moderada (κ = .54), consistência interna alta (α = .92) e o número de itens da escala foi cortado pela metade com base na assimetria, correlação item-total e funcionamento diferencial do item. Voluntários do Estudo 2 foram 322 atletas de elite. Análise fatorial exploratória revelou um único fator, enquanto a análise fatorial confirmatória confirmou uma estrutura hierárquica de primeira ordem com um fator geral. Validade convergente mostrou correlação moderada entre este instrumento e outra medida de imagem mental (*r* = .54). O novo instrumento mostrou boas propriedades psicométricas e se revelou uma medida confiável para avaliar a prática de imagens mentais na abordagem PETTLEP.

Palavras-chave: imagética, PETTLEP, psicometria, esporte

Desarrollo y Propiedades Psicométricas del Inventario Deportivo de Imágenes Mentales PETTLEP (IDIMP)

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Resumen

PETTLEP es una perspectiva aplicada basada en evidencias pensada para permitir a los atletas a practicar imágenes mentales vívidas. El presente artículo tiene como objetivo desarrollar y evaluar las propiedades psicométricas de un instrumento basado en la PETTLEP que mide la habilidad de los atletas en usar imágenes mentales de acuerdo con ese modelo. El estudio 1 tuvo 2 especialistas y 283 atletas principiantes. La confiabilidad inter-observadores fue moderada (κ = .54), consistencia interna alta (α = .92) y el número de ítems de la escala fue cortado a la mitad con base en la asimetría, correlación ítem-total y funcionamiento diferencial del ítem. Voluntarios del Estudio 2 fueron 322 atletas de élite. El análisis factorial exploratorio reveló un único factor; el análisis factorial confirmatorio corroboró una estructura jerárquica de primer orden con un factor general. La validez convergente mostró una correlación moderada entre este instrumento y otra medida de imagen mental (r = .54). El nuevo instrumento mostró buenas propiedades psicométricas y se reveló una medida confiable para evaluar la práctica de imágenes mentales en la perspectiva PETTLEP.

Palabras-clave: imágenes mentales, PETTLEP, psicometría, deporte

Introduction

Imagery is a set of mental processes involved in rehearsing and imaging a task in mind (Bock, Schott, & Papaxanthis, 2015). Sport psychologists and practitioners encourage athletes to image their skills, game plans and emotional control (Filgueiras, 2010, 2016a, 2016b; Hall, Rodgers, & Barr, 1990; Holmes & Collins, 2001; Paivio, 1985; Rúbio, 2008; Wakefield, Smith, Moran, & Holmes, 2013). Imagery in sports show improvement in several aspects (Rúbio, 2008): motivation towards competitions and practices (Kizildag & Tiryaki, 2012), learning new skills (Filgueiras, 2010) and consolidating those already known (Filgueiras, 2016b), design different and new competition strategies (Wei & Luo, 2010), emotional arousal and control (Callow, Hardy, & Hall, 2001).

Literature reviews tend to point out that imagery is an evidence-based practice and its use in sport has three clear benefits: skill and strategy learning and performance, cognitive modification, and arousal and anxiety regulation (Martin, Moritz, & Hall, 1999; Wakefield et al., 2013). Despite of benefits, there are several different theoretical approaches and practice models, for example: there are ten different theories that explains different sets of mental processes known as imagery (Annett, 1995). On the other hand, regarding sports, there are two main applied models to practice imagery: the Integrative Framework for Imagery Effects (IFIE)(Martin et al., 1999) and the Physical, Environment, Task, Timing, Learning, Emotional and Perspective (PETTLEP) approach (Holmes & Collins, 2001; Wakefield et al., 2013).

Martin's integrative model combines tactical, technical and emotional aspects of competitions with changes in perspective and modality (i.e., internal and external visual and kinesthetic imagery) and, also, vividness of mental images (Martin et al., 1999). There are several assessment instruments to measure those dimensions separately or integrated. Examples of those instruments are: (a) the Sport Imagery Questionnaire (SIQ)(Hall, Mack, Paivio, & Hausenblas, 1998), that has a Brazilian-adapted version (Filgueiras, 2016b; Filgueiras & Hall, 2017), it assesses the frequency an athlete uses cognitive and motivational imagery (Ruiz & Watt, 2014); (b) the Sport Imagery Ability Questionnaire (SIAQ)(Williams & Cumming, 2011) that also has an Brazilian-adapted version (Filgueiras, 2017) that measures the ability of sportsmen and women to image tactical, technical and motivational aspects of his sport type; and (c) the Movement Imagery Questionnaire – Third Edition (MIQ-3)(Williams et al., 2012), that presents a Portuguese-adapted version (Mendes et al., 2016), but not yet a Brazilian adaptation, it assesses the ability of an individual to conduct external and internal visual imagery and kinesthetic imagery. Then, it seems that the integrative imagery model has good, reliable and Brazilian-adapted scales to measure imagery under this perspective.

On the other hand, PETTLEP is an applied approach, a guideline to produce good and vivid images in mind. There are significant evidence suggesting that PETTLEP-based interventions are effective to improve performance (Battaglia et al., 2014), motivation (Lin, Lin, & Hsieh, 2016), focus of attention (Collins, Carson, & Toner, 2016), skill learning and vividness (Anuar, Cumming, & Williams, 2016). Holmes and Collins (2001) developed this evidence-based guideline based on previous findings that compared seven distinct aspects of imagery with significant differences between independent variables such as motivation and skill performance (Hall et al., 1990; Porro et al., 1996; Roure et al., 1998).

PETTLEP is an acronym for those seven applied dimensions: physical, environment, timing, task, learning, emotion and perspective; whenever an athlete goes to practice imagery, he/she produces better mental images if he/she attends to these aspects altogether (Holmes & Collins, 2001). Physical entails a modality of imagery: motor image involves feeling the movement and focusing attention to mechanical aspects of a movement or technique while feeling one's own body executing it. Environment relates to elements involved in a competition such as crowd, referee, the court, the ball, the pool and all the other things associated with the atmosphere of the competition. Timing involves the pace that mental image plays inside one's mind: it can be slow motion or real-time images and it provides different observations for the athlete while alternating imagery pace. Task associates image with the skill itself; the best performance on each technique or skill should be imagined in order to have the best outcome possible. Learning is also associated to performance, but this element entails the learning process involved in acquiring a specific skill set; thus, one should produce images of the learning process, from the easiest way to execute to the hardest way to execute to consolidate this skill. Emotion entails the emotional arousal related to the atmosphere of the competition; during images, the athlete should feel the excitement, anxiety and any other emotion associated with sport practice. Perspective involves internal and external points of view during imagery practice; it relates to see from inside and outside one's own body in a way that change of perspective provides information on skill learning and performance.

Accordingly, there is evidence suggesting that PETTLEP-based interventions are linked to individual differences in imagery ability and imagery use (Anuar et al., 2016; Lin et al., 2016; Wakefield et al., 2013). However, there is no way to determine whether an athlete is practicing all seven elements in a balanced fashion, as it should be. Sport psychologist are not available the whole time and tend to travel less than they should with their own athletes (Brandão & Machado, 2008), so there might need information from their sportsperson regarding one's PETTLEP imagery ability and progress of intervention. Nonetheless, probably because PETTLEP was designed as an evidence-based guideline, not as a theory, there are no measures to assess the quality and individual differences of those interventions. The present research aims to develop and assess the psychometric properties of a PETTLEP-based questionnaire designed to measure individual differences regarding each element of this applied model.

Study 1

The first study involves the development and preliminary statistical analysis of the Sport Imagery PETTLEP Inventory (SIPI). The development of the instrument was conducted through four steps under guidelines of the psychometrics literature (Cohen & Swerdlik, 2009; Furr & Bacharach, 2014; Nunnally & Bernstein, 1994): (1) to establish dimensions or facets founded in the adopted theory or model; (2) develop items related to each facet; (3) to analyze items based on experts' and specialists' opinions; (4) to collect data in a pilot-study and discard items with problems according to the sample such as asymmetry, unclear instructions or writing, or item's contribution to facet's or test's total score.

Indeed, Wakefield et al. (2013) draws some important attributes of PETTLEP's facets to conduct any research. First, physical facet entails either auditory or haptic afference, thus physical can be defined as the ability to feel an image by either hearing or sensing hapictically, not visually (because visual imagery is covered by perspective)(Holmes & Collins, 2001). Second, environment is defined as imaging crowd, court and other aspects of the competition, thus it is not associated to any tactical, technical or emotional aspect of imagery (Wakefield & Smith, 2009). Third, task should consider transient and intransient conditions, i.e., transient entails movement and technical aspects of a task such as a free throw or a gymnastic jump, whereas intransient represents motor and motionless aspects of a task such as posture and steps of an execution (Anuar et al., 2016).

Fourth, timing should be divided between slow motion and real-time execution; a good mental image needs both aspects (Lin et al., 2016). Fifth, learning can also be considered level of expertise, because elite athletes show increased vividness and ease to image when compared to amateur, thus, learning entails level of expertise related to a skill (Wakefield et al., 2013). Sixth, emotion reveals the amount of quality of an image because athletes should feel emotions equalized with the situation for every image (Lin et al., 2016). Seventh, and finally, perspective is the most complex of those facets and is represented by the variability of perspectives an athlete can take during image: allocentric and egocentric, kinesthetic and visual. Perspective can be integrated in four conditions: first-person (egocentric) feeling the movement of muscles (kinesthetic), first-person imaging the best technique (visual), third-person (allocentric) feeling the movement of muscles and third-person viewing the best technique (Callow, Jiang, Roberts, & Edwards, 2016; Wei & Luo, 2010; Wilson et al., 2016).

Method

Participants

The first two steps of this study did not need participants. The third step of this study had 2 specialists in Sport Psychology with well-known expertise with applied imagery to analyze items. The fourth step of this study had 283 participants from 3 types of sport: football (*N* = 125), gymnastics (*N* = 85) and volleyball (*N* = 73). All participants were amateur athletes recruited in clubs and teams and agreed to volunteer.

Procedure

The first step followed guidelines from the literature (Cohen & Swerdlik, 2009; Furr & Bacharach, 2014; Nunnally & Bernstein, 1994) by establishing facets of the proposed model. There were seven different facets to distinguish according to PETTLEP applied model: physical, environment, task, timing, learning, emotion and perspective; each mental image created by the athlete have to take all facets into account. The reason why the present study adopted facets instead of factors is because factors assume that one dimension explains part of the common variance by itself, thus separately from other factors; whereas facets are theoretical categories, but not necessarily need to show empirical distinctions (Linacre, 2002).

The PETTLEP applied model proposes that an image must consider several facets at the same moment in order to be imaged correctly, for example: a volleyball player who wants to image her serve must take into account: the haptic sensation of the ball (Physical), the crowd (Environment), muscles needed to be in motion and the serve itself (Task), the time passing slowly such as executing the serve in slow motion (Timing), the best serve possible based on everything this player's expertise in volleyball (Learning), the feeling of excitement or anxiety attached to the responsibility to serve well (Emotion) and all this have to happen from a visual first-person perspective (Perspective). It means that those facets are hard to separate and probably they will not explain different parts of the common variance. The suggestion of the present research is to build a single-factor inventory with seven facets.

The second step of this study was to create items based on each facet of PETTLEP applied model. Because it was expected to reduce the number of items, then eight items were developed for each facet. There were two reasons to build eight items per facet: first, perspective needs at least four items to combine internal and external with allocentric and egocentric imagery, second, it was decided to have the same number of items per facet; thus eight (two items per combination in perspective) was the minimum possible to have a way to reduce items.

Items were adapted to a Likert-based scale of response with six categories. The option to adopt even number of categories was based on recommendations from Linacre (2002) to force participants to avoid indifferent answers. Instructions asked participants to answer according to their abilities to image each situation and categories were: "1 – Impossible to image", "2 – Very hard to image", "3 – Hard to image", "4 – Easy to image", "5 – Very easy to image" and "6 – Imaging it feels natural".

The third step of this study was to invite 2 Sport Psychologists with recognized knowledge and practice in imagery. Each expert was asked to analyze each item independently according to PETTLEP applied model (Holmes & Collins, 2001; Wakefield et al., 2013). They answered to the question "Is this item clear and adequate to the construct?" in a three-point Likert-type scale: "1 – Not clear and not adequate", "2 – Clear, but not adequate; or adequate, but not clear" and "3 – Clear and adequate". Specialists were also asked to suggest improvements whenever they consider important.

The fourth step of Study 1 was to collect data to run preliminary analyses. Amateur athletes of four types of sports were recruited at their clubs or teams and asked to volunteer. The ones who agreed to participate received a Term of Consent and a copy of the inventory with 56 items. They filled the material when they had time and sent back by mail to the address provided by the researcher. All procedures were approved by the main researcher Institutional Ethical Committee under protocol #211.250/2016.

Data analysis

Step three of Study 1 was examined through Cohen's kappa for inter-rater reliability (Nunnally & Bernstein, 1994). The cut-off point for Cohen's kappa was considered according to the literature ($\kappa > .20$)(Cohen & Swerdlik, 2009). Average between the two specialists was consider to modify items: those that presented average below the criteria had to be revised ($X < 2.5$).

After revision of items, data collection among volunteers was proceeded and preliminary psychometric properties were examined. Average of participants for each item was calculated as well as distribution. Skewness and kurtosis were measured and items with values below -2.0 and above +2.0 were considered as asymmetric. Cronbach's alpha was examined to assess internal consistency and homogeneity of the set of items in each facet; Cohen and Swerdlik (2009) establish criteria for good internal consistency ($\alpha > .70$)(Furr & Bacharach, 2014). Item-to-total correlation, which measures the amount of an item contribution to total score of the facet was performed. Reference values are established by the literature ($r > .30$); whenever an item shows correlation below this cut-off point, then it is not contributing to the set of items and should be removed (Nunnally & Bernstein, 1994).

A pair-by-pair comparison was performed to assess invariance between groups. The differential item functioning (DIF) based on Rasch-family analysis (more precisely Graded-Response Model [GRM]), which is an 1-parameter Item Response Theory (IRT) model was used (Meredith, 1993; Osteen, 2010). Each facet was considered an independent subscale. It is reported the contrast DIF (Δ DIF) that represents the amount of difficult in the latent trait to a group to endorse an item *versus* the other group; and Welsh's t-test for significance of Δ DIF. Positive values mean the item is easier to the first group, whereas negative values mean it is easier to the second group; for example: when comparing volleyball and football, if we have a significant positive value (e.g., Δ DIF = .56; $p < .05$) it means that it is easier to volleyball players to image this particular situation, whereas negative significant values are interpreted as the opposite. It also means different functioning of an item, thus, variance between groups (Meredith, 1993).

In order to establish clear criteria to choose among the set of items four for each facet, an hierarchical order was designed. Items presenting asymmetric distribution, item-to-total correlation below the cut-off point ($r > .30$) and significant Δ DIF were excluded. Among those that remained, items were included based on: higher item-to-total correlation and lower asymmetry (i.e., Skewness and Kurtosis closer to 0). Descriptive statistics, Δ DIF, Cronbach's alpha and correlations were executed in R software.

Results

Step three of Study 1 showed moderate inter-rater reliability ($\kappa = .54$). The facet with higher average according to the specialists was Timing, whereas the lower average was Task. Table 1 presents step three and step four results.

Table 1 - Arithmetic average of steps three and four of Study 1. Skewness and kurtosis of step four. Item-to-total correlation, alpha if deleted and facet's alpha. Pairwise contrast of Differential item functioning (Δ DIF) between volleyball (V), gymnastics (G) and football (F)

Item	Average		Skewness	Kurtosis	Item-to-total	Alpha if	Facet's	Δ DIF		
	Step three	Step four			Correlation	item deleted	alpha	VxG	VxF	GxF
Physical1	2.5	4.6	1.9	2.1	.37	α = .72		.45*	.58*	.11
Physical2	2.5	4.3	0.3	0.7	.49	α = .71		.21	.10	.14
Physical3	3.0	4.4	-0.4	-0.6	.58	α = .70		-.13	-0.5	-.04
Physical4	1.5	4.4	-0.5	-0.8	.42	α = .72		-.47*	-.04	-.38
Physical5	2.5	4.9	-2.1	-2.3	.29	α = .73	α= .73	.13	-.25	-.14
Physical6	3.0	4.7	-0.3	-0.5	.56	α = .70		-.15	.11	-.06
Physical7	1.0	4.2	-1.4	-1.2	.38	α = .72		.14	.49*	-.41*
Physical8	2.5	4.8	0.4	0.5	.46	α = .71		.03	.04	-.02
Environment1	2.5	4.3	-0.5	-0.8	.56	α = .73		.59*	.68*	-.12
Environment2	2.5	4.6	1.3	1.7	.68	α = .72		.03	.09	-.05
Environment3	3.0	4.1	-0.5	-0.3	.53	α = .73		.05	.09	-.02
Environment4	3.0	4.9	1.2	1.1	.46	α = .75	α= .76	-.48*	-.44*	-.09
Environment5	3.0	4.0	0.4	0.7	.49	α = .74		.08	.09	.03
Environment6	1.5	4.0	-0.5	-0.8	.32	α = .76		.06	.05	.01
Environment7	1.0	4.6	-0.4	-0.7	.21	α = .77		.13	.15	-.05
Environment8	1.0	4.3	2.4	2.7	.44	α = .75		.07	.08	-0.2
Task1	3.0	4.2	-0.9	-1.2	.45	α = .70		.06	.08	-.04
Task2	2.0	4.7	-0.5	-0.4	.38	α = .71		.08	.13	-.09
Task3	2.0	4.8	-0.8	-0.9	.43	α = .70		.04	.08	-.07
Task4	2.0	4.8	-0.9	-1.3	.39	α = .71		.13	.18	-.03
Task5	1.0	4.4	1.3	1.0	.72	α = .67	α= .71	.27	.11	.20
Task6	1.5	4.1	-1.5	-1.8	.58	α = .69		.37	-.03	.45*
Task7	1.5	4.9	0.2	0.3	.64	α = .67		.56*	.09	.41*
Task8	3.0	4.3	-0.7	-0.9	.37	α = .71		.04	.19	-.17
Timing1	3.0	4.1	-0.3	-0.4	.35	α = .88		.08	.11	-.04
Timing2	3.0	4.8	-1.1	-0.9	.68	α = .84		-.05	-.20	-.27
Timing3	2.5	5.1	-0.4	-0.2	.13	α = .90		-.61*	.03	-.54*
Timing4	2.5	4.3	0.5	0.4	.45	α = .86		.06	.09	-.02
Timing5	3.0	4.3	0.7	0.8	.57	α = .85	α= .88	-.13	.04	-.10
Timing6	2.5	5.0	2.7	2.5	.34	α = .88		.08	.19	-.11
Timing7	3.0	4.8	1.1	1.3	.39	α = .88		.46*	.49*	.02
Timing8	2.0	4.4	-0.9	-1.2	.28	α = .88		.56*	-.57*	-.87*
Learning1	1.0	4.6	-0.4	-0.6	.35	α = .74		.43*	.31*	.11
Learning2	1.5	5.2	-0.7	-0.9	.32	α = .74		.04	.09	-0.3
Learning3	1.0	5.0	0.2	0.3	.47	α = .73		.05	.05	.02
Learning4	2.0	4.9	0.5	0.3	.27	α = .74	α= .74	.14	.19	-.05
Learning5	3.0	5.3	-0.9	-0.6	.29	α = .74		.34	.09	.11
Learning6	3.0	5.1	-0.7	-0.9	.17	α = .75		.32	-.41*	-.78*
Learning7	3.0	4.8	1.1	1.2	.36	α = .74		.09	.11	-.04
Learning8	2.5	5.3	-0.6	-0.8	.48	α = .73		.03	.01	.01
Emotion1	2.5	4.2	-0.7	-0.9	.51	α = .79		.04	.06	-.03
Emotion2	2.5	4.0	-0.8	-0.5	.33	α = .81		.09	.08	.02
Emotion3	2.0	4.2	-0.8	-0.9	.43	α = .80		.14	.01	.16
Emotion4	3.0	3.9	1.4	1.8	.14	α = .82		-.03	-.09	-.14
Emotion5	1.5	4.3	0.3	0.7	.15	α = .82	α= .81	.06	.07	.02
Emotion6	2.0	4.5	0.2	0.1	.45	α = .80		-.18	-.25	-.13
Emotion7	3.0	4.7	-0.3	-0.5	.68	α = .78		.03	.19	-.13
Emotion8	3.0	4.1	-0.1	-0.1	.29	α = .81		.08	.13	-.07
Perspective1	3.0	4.3	-0.9	-0.5	.52	α = .82		-.08	-.19	-.22
Perspective2	2.0	4.4	0.8	0.7	.35	α = .83		.09	.08	.03
Perspective3	2.5	4.4	-0.7	-0.9	.36	α = .83		.07	.05	-.04
Perspective4	2.0	3.7	0.3	0.7	.18	α = .84		.13	.18	.11
Perspective5	1.5	4.8	0.6	0.4	.31	α = .83	α= .83	.04	.01	.02
Perspective6	1.5	4.5	-0.8	-0.8	.66	α = .81		.29	.38	.48*
Perspective7	3.0	4.2	-2.1	-2.4	.63	α = .81		.58*	-.42*	-.95*
Perspective8	2.0	4.7	-0.2	-0.3	.34	α = .83		.36	.07	.44*
General Statistics	κ = .54	253.4	-0.4	-0.6	-	-	α = .92	-	-	-

Legend: Bifactor model entails seven correlated factors and an additional general factor, here called General Imagery; whereas Hierarchical model shows a higher-order general factor that explains residual variance not explained by the seven lower-order factors.

Results from the sample of amateur athletes revealed adequate internal consistency that ranged between Task (α = .71) and Timing (α = .88) among facets and overall good homogeneity (α = .92). Regarding asymmetry, Physical, Environment, Timing and Perspective presented 1 asymmetric item, whereas Task, Learning and Emotion did not show asymmetry. Item-to-total correlation showed items below criteria in six of seven facets. Physical, Environment and Perspective had 1 item below criteria, Timing presented 2 items and Learning and Emotion showed 3 items below criteria.

Among facets, only Emotion presented no significant Δ DIF. Environment, Task and Learning had 2 items with significant Δ DIF, whereas Physical, Timing and Perspective had 3 items. Altogether, exclusion criteria were enough to choose four among the set of eight items to be part of the final version of SIPI in five facets: Physical, Environment, Timing, Learning and Perspective. The other two facets, Emotion and Task, higher item-to-total correlation was enough.

Discussion

Preliminary psychometric properties of SIPI showed good internal consistency, which means that items were built according to a pattern (Cohen & Swerdlik, 2009). Those results also suggest that the set of items can represent PETTLEP applied model (Holmes & Collins, 2001; Wakefield et al., 2013) and measure individual differences regarding imagery practices. The adopted method allowed the research to choose the less biased items: asymmetry was maintained among all items that became part of the final version of SIPI. Indeed, asymmetry is an important part of psychometrics (Furr & Bacharach, 2014), because it is expected of an item to assess the whole continuum of a construct.

Despite of asymmetry, invariance between groups is also pivotal to ensure an unbiased instrument (Meredith, 1993; Osteen, 2010). DIF was performed to understand how items behave while comparing groups and some of them actually were easier for some groups than other. Whenever an item reveals DIF it also means it assesses the construct differently between groups (Osteen, 2010). Excluding those biased items is really important to develop the best measure possible.

Because Linacre (2002) clearly differentiate factor and facet, at this moment of the research there is no say about factor. A final version of SIPI with 28 items (4 per facet) was built and further studies should address the latent structure issue. Regardless, each facet was treated as an independent subscale and showed good statistical outcomes as well as the whole scale. However, it yet remains to be studied other psychometric characteristics such as factor analysis, preliminary norms and standardized scoring.

Study 2

The second study of the present paper uses the final version of SIPI developed in Study 1 to assess its psychometric properties. One of the main questions that remained from the first study was the latent structure of the scale. According to Linacre (2002) facet is a theoretical separation of items inside the same construct, however there is no assumption of an empirical distinction. Factor, on the other hand, entails grouping items according to the amount of common variance explained by each empirically separated element of the construct, thus, those items belong to a similar, but independent construct, named dimensions or factors (Cohen & Swerdlik, 2009; Furr & Bacharach, 2014; Linacre, 2002). Whenever an athlete practice imagery based on PETTLEP, all seven elements come together (Anuar et al., 2016; Holmes & Collins, 2001; Lin et al., 2016; Wakefield & Smith, 2009; Wakefield et al., 2013; Wei & Luo, 2010). Because of that, the present research adopted a facet view of PETTLEP, however, it remains to be tested whether the seven elements of the model are independent or related under the same latent factor.

Another important part of a psychometric research is validity. Convergent validity is known as the linear relationship ($r > .30$) between two instruments that are meant to measure similar constructs and it is one of the more reliable forms of validity (Furr & Bacharach, 2014). It is expected of a PETTLEP based measure to correlate moderately with instruments that assesses Martin's (1999) integrative model. On one hand, those models try to explain imagery as a mental process, on the other hand, one is a theoretical framework, whereas the other is an applied model. Thus, a moderate-to-low correlation can be expected.

Finally, it is also pivotal to develop norms and standards to further use of the measure (Nunnally & Bernstein, 1994). It allows comparison between individuals. To develop preliminary standardized scores is not the objective of the present research; in fact, these data sought only to test balancing between scores of SIPI as evidence of reliability and stability rather than provide norms for practitioners. Nevertheless, it is important to provide some references for future studies.

Method

Participants

The second study had 322 volunteers from two types of sports: karate (N = 202) and football (N = 120). Participants from study 1 were excluded from study 2. All participants agreed to participate by signing a Term of Consent. The present study aimed to respect the rule of 10 participants per item to conduct latent structure studies (Furr & Bacharach, 2014). It argues that the number of participants in factor analysis should be at least 10 per item (SIPI has 28 items; thus, at least 280 participants) in order to provide enough variance to explain the model.

Instruments

Sport Imagery PETTLEP Inventory (SIPI) – It is a 28-items instrument developed to measure athlete's ability to practice imagery under PETTLEP applied model. Items are divided in 7 facets (4 items per facet): physical, environment, timing, task, learning, emotion and perspective; and participants are asked to respond each item in a 6-category Likert-type scale.

Sport Imagery Questionnaire (SIQ) – It is a 30-items instrument created by Hall et al. (1998) that assesses five factors of imagery: cognitive specific (CS), cognitive general (CG), motivational general – arousal (MG-A), motivational general – mastery (MG-M), motivational specific (MS). Participants are asked to respond items in a 7-point Likert-type scale that measures the frequency of imagery practice of each factor (Filgueiras, 2016b).

Procedure

Participants were recruited from their clubs and teams. All volunteers were elite athletes of karate and football and agreed to participate. One block of paper-based questionnaires were given to participants in the same order: (a) Term of Consent, (b) SIPI, (c) SIQ. After completing the questionnaires, participants returned the material to the researcher. All procedures were approved by the main researcher Institutional Ethical Committee under protocol #211.250/2016.

Data analysis

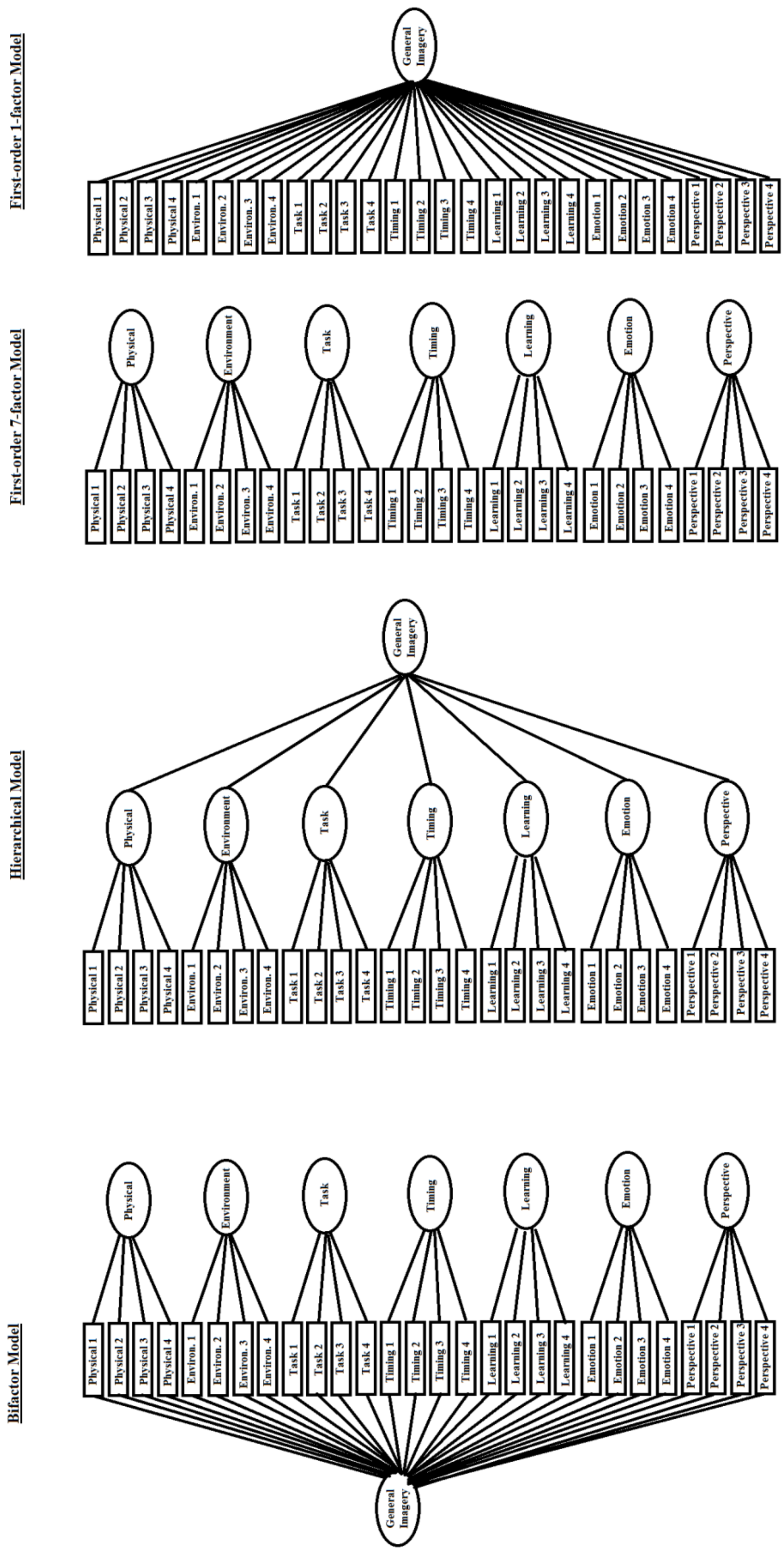
Average and Standard Deviation for each item was calculated. Internal consistency was examined by Cronbach's alpha ($\alpha > .70$) (Nunnally & Bernstein, 1994). Invariance between groups was assessed using Δ DIF and Welsh's t-test (Meredith, 1993; Osteen, 2010). Regardless, invariance was tested after latent structure was established.

Standardization of scores respected z-score procedure (Cohen & Swerdlik, 2009) by establishing ordinal values to percentiles within an interval of 5%. The lowest z-score was 0 relative to percentile 1 and the highest z-score was 20 relative to percentile 99. Values for percentiles 5 (z-score = 1), 10 (z-score = 2), 15 (z-score = 3), 20 (z-score = 4), 25 (z-score = 5), 30 (z-score = 6), 35 (z-score = 7), 40 (z-score = 7), 45 (z-score = 8), 50 (z-score = 10), 55 (z-score = 11), 60 (z-score = 12), 65 (z-score = 13), 70 (z-score = 14), 75 (z-score = 15), 80 (z-score = 16), 85 (z-score = 17), 90 (z-score = 18), 95 (z-score = 19) and 99 (z-score = 20) are reported. Interpretation follows normalization criteria of the literature (Furr & Bacharach, 2014): below percentile 5 is considered low, between percentiles 6 and 25 is interpreted as below average, values between percentiles 26 and 75 indicate average scoring, values between percentiles 76 and 95 entail above average scoring, and above percentile 95 is considered high.

Latent structure was analyzed by two procedures: an exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA). Sample was randomly divided in two to perform EFA and CFA. EFA (*N* = 161) was conducted following the recommendations of Jöreskog (2003) and Lorenzo-Seva and Ferrando (2006) for ordinal data with normal distribution and same probability of category endorsement. A tetrachoric correlation matrix was adopted to perform EFA; the extraction method was Unweighted Least Squares, which uses the minimum residuals of a constrained regression to establish item covariance; and retention method was Hull Method, which uses minimum number of items in the same convex figure aiming for an optimal balance between model fit and number of parameters (Jöreskog, 2003; Lorenzo-Seva & Ferrando, 2006). Because factors are supposed to moderately correlate, the obliquus Promin rotation was adopted (Lorenzo-Seva, 1999). Factor loadings were calculated and cutoff criterion is above .40, in case of cross-loading, items were grouped by higher factor loading (Hair, Black, Babin, & Anderson, 2010).

Four models were tested in CFA (*N* = 161): a 1-factor solution, a first-order 7-factor solution, a hierarchical solution and a bifactor solution. Figure 1 depicts the three tested models in the present study. Analysis was conducted following the recommendations of Jöreskog (2003) and Hair et al. (2010). The estimation method was Maximum Likelihood with the covariance matrix to perform the analysis. Fit indexes were adopted according to Byrne (1994) recommendations: two measures of error (Root Mean Square Error Approximation – RMSEA, and Standardized Root Mean Square Residual – SRMR), two indexes to compare the proposed model, the null-hypothesis and the independent hypothesis (Comparative Fit Index – CFI, and Tucker and Lewis Index – TLI) and chi-squares, including degree of freedom and significance (*p*-value). The adopted criteria for CFA was: RMSEA and SRMR≤ .08 (Hair et al., 2010), CFI > .93, TLI> .90 (Byrne, 1994) and ideally non-significant chi-square (Jöreskog, 2003).

Figure 1. Caption: Tested models using confirmatory factor analysis



Finally, a product-moment correlation matrix with SIPI and SIQ data was generated to show convergent validity. Descriptive statistics, Δ DIF, Cronbach's alpha and bivariate correlations were calculated in R software. EFA was performed in the software Factor 10.3 (Lorenzo-Seva & Ferrando, 2006), whereas CFA was conducted in LISREL 9.10 (Jöreskog & Sörbom, 2013).

Results

Descriptive analysis, asymmetry, factor loadings, communality, Δ DIF considering one single factor due to EFA results and Cronbach's alpha of facets are depicted in Table 2. SIPI's internal consistency was high ($\alpha = .84$), whereas facet's Cronbach's alpha ranged from Task ($\alpha = .73$) to Timing ($\alpha = .83$). Because EFA indicates a 1-factor structure, Δ DIF was performed based on the whole set of items; nonetheless, no item showed differential functioning.

Regarding EFA, Kayser-Meyer-Olkin index was high (KMO = .72) and Bartlett's sphericity test was significant (1635.38; $p < .05$) which entails good sample size and adequacy of variance to perform factor analysis. Hull method retained only one factor, variance explained by the first dimension was 51.4% of the common variance. Communalities and factor loadings were all above criteria (see Table 2) which entail a 1-factor solution.

Table 2 - Arithmetic mean, Standard Deviation (SD), Skewness, Kurtosis, Communalities and Factor Loading of EFA, Δ DIF between Karate (K) and Volleyball (V) athletes and Cronbach's alpha of SIPI's facets

Items	Descriptive Statistics		Asymmetry		EFA		Δ DIF	Cronbach's
	Mean	SD	Skewness	Kurtosis	Communalities	Loading	K x V	alpha
Physical1	3.7	1.4	0.4	0.3	0.56	0.43	-.04	α = .76
Physical2	4.1	1.5	1.1	1.3	0.68	0.48	-.03	
Physical3	3.8	1.9	0.8	0.6	0.87	0.65	.09	
Physical4	3.7	1.3	0.3	0.2	0.58	0.71	.11	
Environment1	3.9	1.8	0.2	0.4	0.71	0.82	.24	α = .79
Environment2	4.1	1.3	1.0	0.8	0.73	0.59	-.05	
Environment3	4.0	1.1	1.3	1.2	0.55	0.64	-.07	
Environment4	3.4	1.7	-0.6	-0.4	0.58	0.76	.04	
Task1	3.6	1.4	-0.1	-0.3	0.62	0.42	-.21	α = .73
Task2	3.5	1.7	-0.5	-0.6	0.51	0.57	-.13	
Task3	3.7	1.3	-0.2	0.0	0.71	0.48	.08	
Task4	4.2	1.3	0.9	0.7	0.60	0.46	.11	
Timing1	4.6	1.8	1.4	1.3	0.59	0.58	.09	α = .83
Timing2	4.1	1.8	1.0	1.2	0.64	0.51	-.23	
Timing3	4.3	1.5	1.2	1.0	0.69	0.49	-.02	
Timing4	3.8	1.3	0.4	0.3	0.78	0.78	-.02	
Learning1	4.5	1.6	1.6	1.8	0.83	0.81	.07	α = .75
Learning2	3.8	1.7	0.4	0.2	0.81	0.54	.08	
Learning3	3.6	1.5	-0.5	-0.6	0.59	0.69	.26	
Learning4	4.1	1.9	0.8	1.0	0.78	0.54	-.04	
Emotion1	4.0	1.2	0.6	0.4	0.56	0.76	-.09	α = .82
Emotion2	3.7	1.7	-0.3	-0.4	0.55	0.49	.01	
Emotion3	4.2	1.1	0.9	1.1	0.87	0.91	-.19	
Emotion4	4.1	1.9	0.7	0.5	0.89	0.94	-.12	
Perspective1	3.7	1.6	-0.4	-0.5	0.65	0.64	.06	α = .78
Perspective2	3.5	1.3	-0.8	-0.6	0.77	0.71	.08	
Perspective3	3.9	1.6	-0.1	-0.3	0.56	0.59	.11	
Perspective4	4.4	1.8	1.2	1.1	0.63	0.66	-.22	

Note: Communalities cut-off point of 0.55 were determined by the literature, as well as factor loadings above 0.40 (Hair et al., 2010). There were no items beyond criteria for asymmetry, communalities, factor loading and Δ DIF.

Results of CFA (Table 3) indicate Hierarchical solution as the only possible model to explain data. It means that latent structure of SIPI is a 7-factor lower-order and a 1-factor higher-order model. Regardless, no model was non-significant, on the other hand, all models showed CMIN/DF between 1.0 and 5.0. The only model to fit all indexes according to criteria was the Hierarchical model, followed by the Bifactor model which CFI remained below established cut-off point. All in all, the 1-factor structure revealed by EFA was confirmed, however, the 7-factor organization cannot be discarded, because they contribute to the higher-order factor (General Imagery).

Table 3 - Results of CFA: qui-square statistics (CMIN), degree of freedom (DF), CFI, TLI, RMSEA and RMSR

Model	CMIN	DF	CMIN/DF	*p*-value	CFI	TLI	RMSEA	RMSR
First-order 1-factor	1062.37	223	4.8	$p < .01$	.86	.83	.12	.09
First-order 7-factors	963.14	223	4.3	$p < .01$	.80	.81	.11	.09
Hierarchical*	863.10	210	4.1	$p < .05$	.97	.97	.03	.02
Bifactor	909.30	210	4.3	$p < .05$	.88	.92	.05	.07

Note: * Model with the best fit: significant difference for incremental fit indexes due to differences above .05 (Byrne, 1994) between Hierarchical and Bifactor models (Δ CFI = .09 and Δ TLI = .05).

Convergent validity performed as expected. Linear relationship between overall scores of SIPI and SIQ was moderately significant (r = .54; p < .05). SIPI's facet less related to a SIQ's dimension was Task (SIPI) and Motivational General – Mastery (SIQ) that showed non-significant correlation (r = .11); whereas the highest association happened between Physical (SIPI) and Cognitive Specific (SIQ) that presented moderate correlation (r = .41; p < .05). Product-moment correlation matrix reveals all linear associations between SIPI and SIQ (Table 4).

Table 4 – Product-moment correlation matrix between SIPI and SIQ: total scores and factor/facets scores

Product-Moment Correlation Matrix														
Scores		1	2	3	4	5	6	7	8	9	10	11	12	13
1	SIPI - Total Score	-												
2	SIQ - Total Score	.54*	-											
3	SIPI - Physical	.46*	.16	-										
4	SIPI - Environment	.63*	.23*	.21*	-									
5	SIPI - Task	.41*	.26*	.43*	.35*	-								
6	SIPI - Timing	.68*	.12	.19	.32*	.28*	-							
7	SIPI - Learning	.41*	.18	.53*	.39*	.24*	.45*	-						
8	SIPI - Emotion	.76*	.24*	.31*	.42*	.35*	.39*	.42*	-					
9	SIPI - Perspective	.71*	.27*	.30*	.48*	.21*	.48*	.34*	.43*	-				
10	SIQ - CS	.22*	.49*	.41*	.23*	.18	.22*	.23*	.32*	.26*	-			
11	SIQ - CG	.24*	.47*	.20	.27*	.26*	.20	.29*	.28*	.21*	.57*	-		
12	SIQ - MG-A	.45*	.51*	.13	.31*	.34*	.17	.20*	.21*	.18	.34*	.22*	-	
13	SIQ - MG-M	.31*	.39*	.18	.24*	.11	.32*	.16	.23*	.26*	.41*	.18	.43*	-
14	SIQ - MS	.28*	.28*	.15	.20*	.19	.31*	.24*	.25*	.20*	.32*	.26*	.33*	.39*

Note: * p < .05; factor and facet scores were the sum of items for each subscale.

Preliminary standardized scores (z-scores) and percentiles are depicted in Table 5. Values remained similar across facets. Also, general imagery has norms provided based on sum of items.

Table 5 – Preliminary standardized scores of SIPI: sum of all items (total score), and sum of four items of each facet

Percentile	Z-score	Sum of items							
		SIPI - all items	Physical	Environment	Task	Timing	Learning	Emotion	Perspective
1	0	29,8	9,7	9,8	9,1	9,2	8,6	10,4	9,0
5	1	43,6	10,3	10,6	9,8	10,0	9,4	11,0	9,9
10	2	57,4	10,9	11,4	10,5	10,8	10,2	11,6	10,8
15	3	71,1	11,6	12,3	11,1	11,6	10,9	12,4	11,4
20	4	78,0	11,9	12,7	11,5	12,0	11,4	12,6	12,0
25	5	84,9	12,2	13,1	11,9	12,4	11,9	12,8	12,6
30	6	90,0	12,9	13,7	12,6	13,2	12,7	13,6	13,3
35	7	95,1	13,6	14,3	13,3	14,0	13,5	14,3	13,9
40	8	100,2	14,3	15,0	14,1	14,8	14,2	15,1	14,6
45	9	105,3	15,0	15,6	14,8	15,6	15,0	15,8	15,2
50	10	110,4	15,7	16,2	15,5	16,4	15,8	16,6	15,9
55	11	114,9	16,2	16,7	16,0	16,9	16,2	17,0	16,2
60	12	119,4	16,7	17,3	16,4	17,5	16,6	17,3	16,6
65	13	123,9	17,3	17,8	16,9	18,0	17,0	17,7	16,9
70	14	128,4	17,8	18,4	17,3	18,6	17,4	18,0	17,3
75	15	132,9	18,3	18,9	17,8	19,1	17,8	18,4	17,6
80	16	135,9	19,0	19,8	18,2	19,8	18,5	19,2	18,7
85	17	138,9	19,7	20,6	18,6	20,5	19,2	20,0	19,7
90	18	141,8	20,4	21,5	18,9	21,1	19,8	20,8	20,8
95	19	144,8	21,1	22,3	19,3	21,8	20,5	21,6	21,8
99	20	147,8	21,8	23,2	19,7	22,5	21,2	22,4	22,9

Note: Interpretation of z-scores are as follow: if the sum of items is below percentile

5: Low; between 6-25: Below average; between 26-75: average; between 76-95: Above average; above percentile 95: high.

Discussion

Results of Study 2 indicate good psychometric properties and regular preliminary standardized norms to facets and total scores. Internal consistency measure by Cronbach's alpha was congruent to Study 1 and remained above the criteria (Cohen & Swerdlik, 2009; Furr & Bacharach, 2014; Hair et al., 2010). According to those results, the set of items is homogeneous and each one contributes to scores.

Invariance measured by Δ DIF showed no differential functioning of items between karate fighters and volleyball players (Meredith, 1993). It means that there are no easier or harder items to none of those types of sports (Osteen, 2010), however this affirmative is limited to karate and volleyball, so future studies of SIPI validity should take into account other sports. Because there was no evidence of variance between groups (Osteen, 2010)(Meredith, 1993) and asymmetry was not present in any item (Cohen & Swerdlik, 2009), norms were established with the whole sample. Interestingly, sum of items were similar across facets and z-scores showed proximity, which gives further evidence of reliability. Those information contribute to establish SIPI as a preliminarily standardized instrument among athletes, however, there is evidence of different imagery frequency between experts and novice sport practitioners (Callow et al., 2001; Filgueiras, 2017; Hall et al., 1990). The present study was conducted with a sample of elite sportsmen, then, new research considering those differences should be considered.

Latent structure studies revealed a hierarchical model with 7 second-order factors (SIPI's facets) and 1 first-order general factor (General Imagery). Accordingly, a hierarchical structure is the best definition of facet, because it entails a single-factor that relates in lower-order theoretical structure to be organized (Linacre, 2002). It means that, indeed PETTLEP is a unidimensional applied model (Anuar et al., 2016; Holmes & Collins, 2001; Wakefield et al., 2013), however, its elements can be considered independently, thus, they do not need to be associated across all facets, relying exclusively in a higher-factor: General Imagery. In practical terms, an athlete can image from the first-person perspective, but not necessarily he/she is going to image the environment around him/herself, those are empirically independent constructs. On the other hand, imagery ability and practice relies on those elements altogether.

General Discussion

The present study aimed to develop the Sport Imagery PETTLEP Inventory (SIPI) to assess athletes ability to image using PETTLEP applied model (Holmes & Collins, 2001; Wakefield et al., 2013). Two studies were performed to develop and evaluate the psychometric properties of the final version of SIPI. Study 1 results showed moderate inter-rater reliability (Hair et al., 2010), good internal consistency (Cohen & Swerdlik, 2009; Furr & Bacharach, 2014) and scale reduction based on asymmetry (Nunnally & Bernstein, 1994), item-to-total correlation (Cohen & Swerdlik, 2009) and differential item functioning (Meredith, 1993; Osteen, 2010). Holmes and

Collins (2001) suggest that PETTLEP is am evidence-based applied model to help sport psychologists and practitioners to guide imagery efficiently. The development and empirical evidence provided by Study 1 corroborate with the literature indicating that modelled elements are indeed important and homogeneous to promote consistent (Lin et al., 2016) and vivid mental images (Anuar et al., 2016).

From Study 1 results, a final version of SIPI was built with 28 items, divided in 7 facets: Physical, Environment, Task, Timing, Learning, Emotion and Perspective, the acronym of PETTLEP (Holmes & Collins, 2001; Wakefield et al., 2013). This applied model was thought as unidimensional (Holmes & Collins, 2001), or at least the neural network involved is the same for all elements (Wakefield et al., 2013). Further latent structure analysis using CFA (Hair et al., 2010) revealed a hierarchical solution to explain common variance of SIPI data. The higher-order dimension was called General Imagery and it is a product of the combination of PETTLEP elements, thus, one dimension dependent of the seven facets, which corroborates with the literature (Anuar et al., 2016; Holmes & Collins, 2001; Lin et al., 2016; Wakefield & Smith, 2009; Wakefield et al., 2013; Wei & Luo, 2010).

Study 2 also indicates that integrative model of imagery (Martin et al., 1999) and PETTLEP (Holmes & Collins, 2001; Wakefield et al., 2013) correlates moderately. It probably happened because Martin's integrative model is thought to combine several aspects of imagery as a theoretical model (Callow et al., 2001; Hall et al., 1990; Martin et al., 1999), whereas PETTLEP is an evidence-based set of guidelines to produce good and vivid images (Anuar et al., 2016; Lin et al., 2016). It is not expected that PETTLEP-based measures associate highly with other imagery models because it is not intended to be theoretical. Being an applied model allows PETTLEP (Wakefield et al., 2013) to be measured regarding its practices, but it does not imply any explanation about a theory to explain mental processes involved in imagery.

Overall, results of the present paper suggest that SIPI is a reliable, homogeneous, valid and asymmetric assessment measure that respects PETTLEP assumptions as an applied model. Preliminary standardized scores seem to allow comparison between facets of SIPI; nonetheless, full norms are not provided due to limitations in the sample. Although the present study presented several empirical evidence and different statistical analyses, there still questions about SIPI such as: differences between elite and amateur athletes (Anuar et al., 2016), divergent validity and test-retest reliability (Furr & Bacharach, 2014; Nunnally & Bernstein, 1994). Future studies may answer those questions and help to further develop SIPI.

Limitations and Future

The present study sought to develop an instrument to measure imagery ability and development through time based on the PETTLEP applied approach (Holmes & Collins, 2001). Regardless of some success, this paper is limited to some psychometric properties and it does not provide reliable norms, but preliminary values of reference for standardized scores. It seems that the absence of those elements might impair SIPI use among practitioners; however, to develop full norms (21 percentile points) based on athletes from only four distinct types of sport seem inadequate. There is evidence suggesting that imagery use is different across sport categories (Filgueiras & Hall, 2017; Ruiz & Watt, 2014); thus, it would be inconsequent to develop norms with the present sample.

The same phenomenon happens toward imagery ability through time. There is evidence that imagery use is linked to improvement on imagery abilities (Gregg, Hall, McGowan, & Hall, 2011). SIPI is intended to provide sport psychologists information regarding the development of imagery skills of athletes; then, a longitudinal study must be conducted before enabling the use of SIPI among practitioners. Based on the previously outlined limitations, future endeavors of SIPI research involve: comparing sport categories and level of competitions, longitudinal data, test-retest reliability and development of full norms based on several types of sport rather than just four.

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